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EDITED BY

C. L. HERRICK.

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THE CLINTON GROUP OF OHIO.—PART IV.

BY A. F. FOERSTE.

CHEMICAL GEOLOGY.

The Silurian rocks of Ohio open with the Cincinnati Group. This group is composed of a series of limestones interbedded with shales or clay. Neither the limestones nor the shales are magnesian in character, the carbonate of magnesia rarely exceeding six per cent. The amount of silica, however, varies greatly. The lower beds of limestone contain from ten to twenty-five per cent. of silicious matter; there is a corresponding diminution of the amount of the carbonate of lime. The upper part of the series, however, contains very little silicious matter, usually less than two per cent.; the carbonate of lime, however, becomes a much more important constituent, averaging ninety per cent. The interbedded shales differ from the limestones chiefly in the amount of silica contained, there being a corresponding diminution of the carbonate of lime. Thus the amount of silicious matter in the shales varies between fifty-five and eighty per cent.; the amount of the carbonate of lime, between four and twenty per cent. The shales also contain more alumina than the limestones, but the striking difference is evidently the amount of silicious matter contained. In one of the lower series of shales belonging to the Cincinnati Group, but found in Covington, Kentucky, the amount of silicious matter is somewhat less, forty-three per cent., and the amount of the carbonate of lime is much greater, forty-seven per cent. Otherwise the chemi-

cal peculiarities of the shales are quite uniform, differing in this respect from the interbedded limestones.

In Preble county, near Fair Haven, a sandy rock intervenes between the Cincinnati and the Clinton Group. It is about two feet thick. In a fragment of rock lying near by and apparently of the same origin, there was the impression of a large aviculoid shell. In Clinton county, near Wilmington, there is another series of sandy stone between the Cincinnati and the Clinton Groups. The lower part consists of quite heavy stone, about five feet of it are exposed, although there may be more. This contains annelid teeth near its upper courses. These sandy stones are referred to the Medina Group, although there is no paleontological proof to warrant this reference. They do not exist at all in the numerous exposures near Dayton.

Several years ago my friend, Mr. A. B. Knerr, at that time assistant in the chemical laboratory of Wittenberg College, made for me some analyses of the rocks found at Huffman's quarry, southeast of Dayton, and also of one specimen from the Clinton Group, at a hill known as Camp Corwin, east of Dayton. The result is shown in the following table:

Chemical Analysis of Clinton and Niagara Limestone.	Chemical Substance Contained	Niagara Shale.	Dayton Limestone.	Beavertown Marl.	Clinton Dark Red.	Clinton Light Red.	Clinton Dark Green.	Camp Corwin Clinton.
Relative amounts of Calcium and Magnesium Compounds.	$CaCO_3$	46.22	93.23	------	97.75	97.83	65.14	------
	CaO	------	------	25.36	------	------	------	35.03
	CO_2	------	------	31.27	------	------	------	25.03
	MgO	------	------	14.11	------	------	------	.53
	$MgCO_3$	22.38	4.00	------	.22	.75	11.15	------
Sand and Clay Ingredients.	SiO_2	17.85	1.95	18.27	1.03	.28	8.27	6.03
	Al_2O_3	8.76	------	5.55	------	------	2.8	2.13
Amount of Iron Entering into the composition.	$FeCO_3$	2.60	.43	------	.6	.21	3.33	------
	FeO	------	------	3.48	------	------	------	1.29
	Fe_2O_3	------	------	------	------	------	------	28.66
	FeS_2	------	------	------	------	------	6.56	------
Miscellaneous Compounds. Water contained not calculated.	K_2O	1.06	.37	.72	.22	.24	1.19	.34
	P_2O_5	------	trace	------	trace	trace	trace	.87
	TiO_2	------	------	.22	------	------	------	------
	Na_2O	trace	------	------	------	trace	------	------
Total		98.88	99.98	99.98	99.82	99.31	98.50	99.91

Of the specimens here analyzed, those marked "dark red" and "light red" represent the typical forms of Clinton as they occur at Huffman's quarry. With these may be compared the following analyses of Clinton rocks from other parts of the state. Centerville, Montgomery county: $CaCO_3$, 86.30; $MgCo_3$, 11.34; SiO_2, .85. Eaton, Preble county: $CaCO_3$, 85.21; $MgCo_3$, 13.56; SiO_2, .35. Brown's quarry, New Carlisle, Clarke county: $CaCO_3$, 95.60; $MgCO_3$, 3 93; SiO_2, not discovered in the analysis, if present at all, then only in inappreciable quantities. Ludlow Falls, Miami county: $CaCO_3$,, 91.30; $MgCO_3$, 6.51; SiO_2, .80.

Comparing the limestone of the Clinton Group with those of the upper part of the Cincinnati Group, we find a close resemblance in the small amount of silica present in each. The magnesium carbonate, however, which in both the shales and limestones of the entire Cincinnati Group was present only in inconsiderable amounts, now begins to be a very variable quantity, varying from less than one per cent. to almost fifteen per cent. This variation causes a compensating change in the amount of calcium carbonate present. It will also be noticed that the central locality, near Dayton, has the least amount of magnesium carbonate, but that the amount increases in all directions, moderately so towards the northeast, Brown's quarry, and the northwest, Ludlow Falls; but markedly so towards the south, Centreville, and the west, Eaton. In other words there seems to be a slight tendency of the Clinton Group, beginning with Dayton as the center, to become more magnesian towards the circumference of the exposed parts.

The same thing is true, but in a far more marked and satisfactory sense, of the Dayton limestone. Here again the series of quarries of which Huffman's quarry is the center, contain the least amount of magnesium carbonate. At a distance these exposures become more and more magnesian until finally they can no longer be told from the Niagara shales above.

But there is not only an increase in the amount of dolomitisation laterally, but also vertically. To be sure, in Huffman's quarry this change is very sudden. There is a fairly sharp line between the Clinton Group and the Beavertown marl. At Todd's Fork, near Wilmington, Clinton county, they gradually run into each other, and there is a commingling of fossils. The Niagara shale at Huffman's quarry is

also quite distinct from the Dayton limestone beneath. But at Centerville, and numerous other places throughout the state, there is quite a gradual change from one into the other. Whatever may have been the cause of the increase of the carbonate of magnesium, it seems to have originated outside of the special area here described. It began to operate in the Clinton Group. At Todd's Fork the change was rather gradual, but at Huffman's quarry, after dolomitisation elsewhere had became quite advanced, it seems to have come suddenly, remained long enough to deposit the thin Beavertown marl, and then to have retreated again, giving way to the formation of quite a pure limestone again. Meanwhile, on the outskirts of this area the dolomitic character was still maintained, and a second advance of the causes leading to dolomitisation took place, gradual at the outskirts, quite sudden at Huffman's quarry. After this second advance of the cause which may have given rise to dolomitisation, it became permanent, the silicious elements which had accompanied its earlier advance became less, and the comparative amount of dolomite increased until in the Springfield and Guelph, or Cedarville strata, the rock had become a typical dolomite.

It is evident, therefore, that the problems as to the cause of the rapid succession of the limestones and shale or clays of the Lower Silurian is a different one from that of the cause of the insertion of the Beavertown marl and the Niagara shales in the Upper Silurian Group of Ohio. While those of the Upper Silurian were part of a general process of dolomitisation, more or less gradually infecting the sediments of the series, those of the Lower Silurian evidently are the result of a much more rapid and much more frequent alteration. Both of these processes remain still to be explained. Much has been written; it may be equally valuable to examine the question without any special theory in view. The chemical relations of the Clinton Group to the rocks above and below can at least be well established.

It remains to note a few points about the relative amount of iron present in the Clinton Group. In the two analyses from Huffman's quarry noted "light red" and "dark red" it will be noticed how small a variation of the amount of iron present is sufficient to make a marked difference in appearance to the eye. The Camp Corwin specimen is from the uppermost layers of the Clinton Group, at the locality mentioned and is a picked specimen, the usual amount present in

the same layers being much less. The amount of iron becomes greater as well as far more regular in the upper courses of the Clinton Group at Todd's Fork, here becoming oolitic in places. Farther south from this point it increases until it reaches some importance in the southern counties.

The specimen from Huffman's quarry marked "dark green" is a fragment showing localized features of the ordinary limestone of that locality, of small extent, usually existing only as little, often far distant, patches. In the discussion of the chemical character of the rocks here examined the analyses made by Dr. T. G. Wormley, and published in the various volumes of the Ohio Geological Survey have been constantly before my eyes.

STRATIGRAPHICAL GEOLOGY.

Stratigraphically the Clinton Group of Ohio presents no marked subdivision except that of the Beavertown marl, which occurs at Huffman's quarry, and also at Todd's Fork, but not as a marked subdvision. The top of the Clinton at Centreville and the Soldiers' Home quarries, is composed of a few inches of clayey sediments, which present a much larger number of specimens of certain species than are found in the rocks below. These are: *Orthis hybrida*, *O. elegantula*, *G. fausta*, *O. Daytonensis*, *Triplesia Ortoni*, *Calymene Vogdesi* (the larger forms), *Rhinopora frondosa*, and *Homotrypa confluens*. But this seems to be a mere local variation.

A comparison of the Ohio Silurian with the corresponding strata of Indiana is at the present date difficult, owing to the fact that no connected plan of work seems to have been followed in that state, so that observations made are apt to have only very local value, and different writers apparently apply different values to the same stratigraphical names. Careful paleontological observations with the exception of the Waldron beds, are also lacking. Lithological features alone, unfortunately, are so often deceptive that not much reliance can be placed upon them. However the following conclusions seem fairly well drawn.

The Lower Silurian series of Indiana have been well determined. In places, especially in Decatur and the more southern counties, the base of the Upper Silurian is formed by a sandy rock, varying from

a few inches to several feet in thickness, and corresponding in position to with those of Fair Haven and Todd's Fork, in Ohio—the so-called Medina.

The top of the Upper Silurian of Indiana has also been well determined. It consists of the highly magnesian rock known as the Guelph, in Canada, and the Cedarville, in Ohio. It has been identified in Grant, Madison, Delaware, and Randolph counties (13th Rep. Ind. Geol. Surv.); across the line it occurs again in the north of Preble county, Ohio.

In Ohio the Springfield beds have been identified at Eaton, Preble county; and the West Union beds seem to be entirely lacking. The Springfield strata are in reality very closely allied to the Cedarville strata, and are distinguished mainly by the great abundance of the brachiopod, *Petamerus oblongus*, and by the fact that it usually shows a more decided tinge of blue. The blue magnesian rocks immediately to the south of the Guelph series already mentioned may safely be referred here.

In Ohio the Eaton beds extend south, reaching to a distance within four miles of the Clinton exposures at Fair Haven. About two miles north of the latter, the intervening portion is seen to contain limestone beds, and also some cherty layers, one of which is well marked, about nine inches thick, and contains numerous specimens of *Atrypa reticularis*. Now *if* the cherty layers here may be considered fairly equivalent with the cherty beds usually found beneath the Waldron fossil beds of Indiana, then the Waldron beds may fairly be considered the equivalent of the Upper Niagara shales of Ohio and perhaps to contain sufficient association with the Springfield beds to give its fauna a tinge of the facies of the Guelph. The part below the cherty beds in Indiana would then contain the materials recognized in Ohio as Clinton, Dayton, and perhaps the lower part of the Niagara shale strata. The Clinton has been reported from various parts of Indiana, but until the paleontological proofs for such references are given, it will be impossible to make any use of the identifications so far made.

Paleontological facts also bear out these conclusions. The fauna of the Waldron shales has quite a decided relation to the Guelph fossils. It is not a typical Guelph fauna, but it has a facies approaching that of the Guelph and a fair number of species are identical. The

Clinton fauna of Ohio, however, is not at all like that of the Guelph in character, but it possesses some feautures in common with that of the Waldron beds, and a small number of identical species." This would indicate a lower horizon for the Waldron beds than for the Guelph beds, and a still lower one for the Clinton beds of Ohio. The fact that the Clinton Group of Ohio contains a number of fossils signifying a low horizon, such as *Rhinopora verrucosa*, *Phylloporina angulata*, *Leptæna prolongata*, *Strophomena patenta*, *Merstella umbonata*, *Bellerophon fiscello-striatus*, and *Discosorus conoideus*, and the fact that the Waldron beds have no such types, is additional evidence in favor of the lower horizon of the Clinton Group of Ohio. That the Clinton Group of Ohio should begin to assume the facies of the Waldron beds of Indiana, and the Waldron beds of Indiana, that of the Guelph series above, are facts which the paleontologist will recognize as being of frequent occurrence, and indicating consecutive development of life. Moreover, it is not necessary to imagine that the various strata mentioned must either be exact equivalents or entirely distinct from one another. While life ceased at one locality it was still continuous for some time at another, more or less removed, and new types gradually introduced in those localities where life has been consecutive, seem to have been introduced suddenly into the locality where life for a while had ceased, whereas it is only a case of the reintroduction of a faunna in one place after life had ceased for some time, from some other locality where life had been continuous, and where the change of the fauna had been gradual. Geological divisions are after all only convenient methods of reference, and divisions are regulated largely according to the number of breaks in the faunal development of any region. Every experienced paleontologist, however, knows that what are breaks in the development of life at one place are gradually bridged over at some other locality. This feature is in small part shown by the Clinton and Waldron beds of the West. Indeed, the Clinton of Ohio is itself a connecting bridge between the Clinton and Niagara, as shown in New York, and Dr. E. N. S. Ringueberg has found another connecting bridge at Lockport, N. Y., between the divisions themselves. Again, the Anticosti Group of Canadian geologists is a connecting bridge between the Upper and Lower Silurian series of rocks. This illustrates the fact, well known among students of ancient life, that geological divisions are not universally

applicable, but that somewhere or other any dividing line is apt to fail.

Geographical Paleontology.

Reed's Hill.—East of Fairfield, a village near Osborn, is a hill that presents a fair exposure of Clinton rocks. There are about eight feet of it, worked for building stone, of an inferior quality. Neither the line of junction with the higher nor the lower strata was observed here. The stone is of a pinkish, often rose-red color, and is composed of tiny pieces of organic matter, preserving very few fossils in a condition admitting ready recognition. They are: the bases of two kinds of crinoids, *Favosites Niagarensis*, *Rhinopora verrucosa*, a species of *Fenestella*, *Orthis biforata* var. *lynx*, *Orthis fausta*, and several species of cup corals of unknown affinities.

Browns Quarry.—Two and a half miles west of New Carlisle and half a mile south of Brown's Station, on the I. B. and W. R. R., is a quarry presenting a fine exposure of the Clinton Group. The superposed strata of the Niagara Group were not noticed at this locality, although exposures are said to be not far distant. The Clinton rock is of a peculiar white color, which when ground gives it an appearance much like that of chalk. It is comparatively soft, so that the fossils contained are readily dug from the rocks, but they are also easily injured, and not being very translucent they do not admit of good microscopical sections. The ground up rock is sold for marble dust and subserves its purpose very well. A hot lime is burned from the rock which formerly was in large demand in neighboring towns, and is even now used where the management of hot limes is understood. This locality is of almost equal value with that of the Soldiers' Home Quarries, from a paleontological point of view. Brachiopods with the exception of *Rhynchonella*, are rare. The trilobites are well represented and several new species are found. Of these *Ascidaspis Ortoni*, and a *Ceraurus* are the most prominent *Lichas breviceps* and *Pterinea brisa* are very common here, while in the Soldiers' Home quarries they are very rare. *Hemitrypa Ulrichi* is common, also various species of cup corals. Crinoid buttons, which form such a constant feature elsewhere are almost unknown here. Cephalopods of different genera are quite common.

Ludlow Falls.—Most of the Clinton exposures were half covered

by rubbish from neighboring quarries and railroad cuts at the time of examination. The color of the stone is drab and in places dark red. A fragment of the glabella of *Illœnus Daytonensis*, and a movable cheek, probably of the same species were found here. The fauna consists chiefly, however, of various corals, such as *Heliolites*, *Lyellia*, *Halysites*, *Favosites*, *Heliophyllum*, *Diphyllum* and *Streptelasma*. The superposed layers of the Dayton limestone are drab in color, and contain quite a large percentage of magnesia.

Fair Haven.—The character of the fauna is much the same as that of Ludlow Falls, with the exception of certain additions. *Striatopora* occurs in considerable abundance. Trilobites, brachiopods, and gasteropods are rare. On the other hand various bryozoans of the families *Strictoporidæ* and *Monticuloporidæ* are seen in moderate abundance.

Camp Corwin.—A mile east of Dayton lies a long range of hills, the most northern promontory of which is called Camp Corwin. On the crest of several of the hills near by several feet of Clinton rock are seen, of crinoidal structure, with few recognizable fossils. The color varies from pink to deep red. Some of the courses contain a large percentage of iron.

Todds Fork.—The exposures are three miles north of Wilmington, chiefly on the north side of the creek. Five feet of sandy rock referred to the *Medina Group* are exposed. Above this rise eighteen feet of Clinton rock, the lower courses being white limestone, quite heavily bedded, then more reddish rock of the same nature, changing into quite a heavy deposit of reddish rock above, containing much iron. The last bed is the fossiliferous one and has yielded so far: *Illœnus ambiguus*, *I. Daytonensis*, *Proctus determinatus*, *Dalmanites Werthneri*, *Orthoceras Jamesi*, *O. inceptum*, *Raphistoma affinis*, *Orthis elegantula*, *Rhynchonella scobina*, *Strophomena rhomboidalis*, *Phœnopora platyphylla*, *Ptilodictya expansa*, *Clathropora*, *Zaphrentis*, and *Streptelasma*.

A comparison of the faunæ of the different localities so far mentioned will show that there is considerable variation in the distribution of the different species. The most striking feature is the comparative absence of trilobita, gasteropoda, and brachiopoda, and the large development of the corals at Ludlow Falls and Fair Haven, the two more western exposures. In a line almost parallel with these are the Soldiers' Home, Fauver's, and Brown's quarries. In this line the cor-

als, although present to a moderate degree, do not form a marked feature of the enclosed fauna. However, this is the line in which there is a considerable variety in the number of trilobites, brachiopods, and bryozoa. It is especially of value, however, as containing the best general collection of the fossils peculiar to the group in the best condition for the collector's purposes. The localities in line with Reed's Hill, Camp Corwin and the Huffman quarries are the worst localities for collectors of specimens. However, beginning at Huffman's quarry there are a few fossils at the very top of the Clinton proper, and the fauna of the Beavertown marl is also shown. At Centreville the top of the Clinton proper reaches a greater variety in the fauna, and at Todd's Fork, where there is a commingling of the two, the top strata are quite richly fossiliferous again. The question presents itself whether this distribution of the fauna can have any relation to the elevation of the Cincinnati Arch. If so, it would be a most indubitable evidence of the elevation of that arch before the beginning of the Clinton Group.

If there is so much variation in the fauna of even a quite limited district it will be well to note what forms have been found most reliable in the identification of this group, forms therefore which are characteristic and have the widest geographical range. These are: *Illænus Daytonensis*, *Illœnus ambiguus*, *Dalmanites Wertherni*, *Platyostomus Niagarense* (a small and constant form) *Orthis flabella*, *Strophomena patenta*, *Phylloporina angulata*, *Clathropora frondosa*, *Ptilodictya expansa*, the various species of *Phœnopora* and *Rhinopora verrucosa* Any locality in this state or in Indiana, containing five of these species, could safely be referred to the Clinton Group as represented in Ohio.

II.

THE GEOLOGY OF LICKING COUNTY, OHIO,

Part IV. The Subcarboniferous and Waverly Groups.

BY C. L. HERRICK.

In pursuance of the plan outlined in the last volume, material has been slowly accumulating, the collection and collation of literature and unraveling of perplexed synonomy being by far the most onerous task. Nearly every foot of this and much of adjacent counties has been searched by patient collectors and, in spite of the great difficulties, much progress has been made in identifying and referring to their horizons the fossils of the Waverly Group. It is hoped that even as brief a review of the fauna as can now be presented will prove helpful. Perhaps no other limited group of strata in the Palæozoic era has been the theme of more discordant discussion than this one. The problem of the Waverly deserves to rank with that of the Keweenaw and Taconic. While not claiming to settle the points at issue in this paper, it is hoped that the material made accessible by the pictorial and descriptive matter presented will at least afford every competent palæontologist with considerable material upon which to base his opinion. The methods hitherto employed in the study of the Waverly have been fatally lacking in several particulars. Generally the descriptions have been unaccompanied by figures and frequently so hasty as to make it necessary to base our opinion as to the accuracy of the indentification on the reputation of the writer. No published work has given the sequence of the fossils attributed to the Waverly, but in

many cases evidence is wanting as to the fact that the stratum referred to actually belonged in the same group or formation as those with which it was collocated. The question was entirely open as to whether, for example, those species figured in the Ohio Palæontology were distributed throughout the series or were characteristic of limited zones. Many species have been referred to the Waverly, which all precedents show to be true coal-measure forms, while in a few cases Devonian species are brought into curious and unexpected relations with such species. We are quite in the dark as to whether the coal-measure forms are associated in the same actual horizon with Devonian types or whether the collocation of faunæ is more or less arbitrary or, at best, merely a theoretical result of a general survey.

The Ohio Waverly is the natural arena for the settlement of the problem as being the most accessible and the earliest known. These rocks were first confidently referred to the position of the Chemung of New York, but a more extensive comparison has shown that the Waverly is much more closely allied to the carboniferous than was first supposed. Prof. Alexander Winchell, who has given most attention to this series (which he calls Marshall) regards these rocks as the equivalent of at least a part of the strata usually referred to the Oriskany. It is our purpose to defer extended discussion of these points to the close of this series and our use of the term Waverly is to be understood as waiving the matter of terminology, though that name has priority, in Ohio at least, and its use in the restricted modern sense does not involve any ambiguity.

To illustrate what has been said of the great importance and difficulty of stratigraphical determinations we may allude to the condition of our knowledge regarding the equivalent rocks in Michigan. The serial relations in that state are, according to Prof Winchell, as follnws:

Marshall Group, consisting of

1. Napoleon sandstone ..... 123 ft.
2. Marshall sandstone ..... 160 ft.
3. Huron gritstones ..... 15 ft.

Huron Group, consisting of

4. Argillaceous shales and flags ..... 500 ft.
5. Green arenaceous shales ..... 25 ft.
6. Black (Genessee) shale ..... 25 ft.

Hamilton Group.

The Huron Group furnishes "all that is requisite to answer the demands of the Portage and Chemung groups. The thickness is, indeed, considerably reduced; but it must be remembered that all other New York groups traced into Michigan exhibit even a greater attenuation than this parallel would imply."

Enumerating the fossils of the Huron Group in 1870, Prof. Winchell says: "Four of the [19] foregoing species I have identified more or less doubtfully with species of the Hamilton group." "The equivalencies of these rocks are not very precisely indicated from the palæontological data. That the formation is newer than the Genessee shale is demonstrated by its observed superposition. The palæontological evidence indicates, at least, that the fauna is older than that of the Marshall group; and this is all that is necessary. If this group of rocks is proven by stratigraphical superposition to be newer than the Genesee, it belongs either to the horizon of the Portage and Chemung, or to that of the Marshall." "The Huron group, above the black shale, must correspond to the Portage and Chemung or to some portion of them."

Rominger, in 1876, writes: "The light-colored greenish, arenaceous shales on top of the black shale exposed along the shore of Big Traverse bay, may be possibly an equivalent of the Erie shales of the Ohio geologists, but no fossils have been found by which this question can be determined. The shales in the southern part of the peninsula, which were considered by Winchell, as a part of his Huron shales occupy a higher position, and must be identified with the Waverly." "The conformity of rock material and stratification in this part of the formation, above and below the imaginary division line between the Devonian and carboniferous deposits is so perfect that no one would accept this stratum as the terminal deposit of the Devonian ocean, even if the fact were ignored that at least 500 feet of rock beds below this horizon present the faunal characters of the Cuyahoga shales of Ohio, which form the upper division of the Waverly group." The order of sequence as given by Winchell, Rominger declares entirely wrong, claiming that it was based upon a mistake of a synclinical section for a regularly descending one, so that what was regarded by the former as the foot of the section the latter affirms to be the same horizon as that at the opposite extreme. These discrepancies are here pointed out not in order to harmonize them, which would require care-

ful scrutiny of the region in question, but as an excuse for the stress laid upon stratigraphy in this paper. Prof. Rominger again says: "Prof. Winchell considers the sandstones of Marshall as the lower terminus of the carboniferous rock series, typically distinct by its fossils from the next subjacent shaly beds, which he connects with the Devonian rocks by the character of their fauna. Such a difference in the fauna is not perceptible; the fossils of the Marshall sandstones and the subjacent shales are not only generically in full harmony, but a great number of species are common to both." This quotation may serve to justify the care with which the fossils herein noticed are limited to their horizons. It seems sufficiently obvious that central Ohio is the place where the serial relations must be made out, if anywhere, for here the stratigraphical sequence is perfectly unaltered and the horizons well marked. We present the facts collected, confidently believing that they form a firm foundation for the solution of the perplexing problem. The theoretical value of this study cannot be over-estimated. The false theory that "times of peace make no history," has too largely affected our notions of geological history. It is by tracing the succession of living forms during long periods of comparatively uniform conditions that the laws and course of development are to be discovered. Even this brief discussion demands an allusion to the views expressed by the state geologists of Ohio. In the first volume of the final report, Dr. Newberry adduces reasons for considering the Black or Huron shale as the representative of the Genesee plus part of the Portage. The remainder of the Portage and the *whole of the Chemung* is represeuted by the Erie shale, a group of greenish or grayish argillaceous shales limited to the northern part of the state and of small vertical extent. The difficulty of eliminating at one blow from central Ohio the great sandstone and shale series known in New York as Chemung. has, however, militated steadily against this view and most geologists have felt constrained to seek the missing formation in some larger or smaller portion of the Waverly series. It is to be noted that Prof. Newberry at that time contended that "the series of strata which begins with the mechanical sediments of the Portage has a fauna which is much more carboniferous than Devonian in character. The commencement of the epoch of the deposition of this series of mechanical sediments . . . *was in fact* the beginning of the carboniferous period."

In the second volume of the same report Dr. Newberry brings

into still greater prominence the close relation, both faunal and lithological between the Waverly and the carboniferous. The general conclusions formulated are as follows: "That all its rich fauna is of a decidedly carboniferous type; second, that it includes a number of species characteristic of the lower carboniferous rocks of Kentucky, Tennessee, Illinois, Iowa, and Michigan; third, that it furnishes at nearly all of its fossiliferous localities certain species which are also common in the coal-measures above; fourth, that our collections made include no Chemung or Portage species; fifth, that it is continuous with the "vespertine" and "umbral" rocks of Pennsylvania."

The subdivisions of the Waverly are as follows:

The conglomerate (coal meas)

1. Cuyahoga shale.....150–250 ft.
2. Berea Grit.....60 ft.
3. Bedford shale.....75 ft.
4. Cleveland shale.....20–60 ft.

Erie shale (Chemung.)

It is to be noted here that what has since been called the Logan sandstone, which makes up the bulk of the exposed part of the formation south of the middle of the state is here omitted (probably as being identical with the Berea.) But doubtless nearly all the fossils, on which the judgment pronounced as to the carboniferous age of the series was founded, were actually derived from this part, i. e. our series III. The Cuyahoga or the upper part of it added to this habitus remarkably. The careful study of the Cuyahoga will, I think, surprise geologists. If not actually a part of the coal-measure series, it has curious premonitory symptoms.

Prof. E. W. Claypole, who incidentally discusses this question in a paper read in 1884, gives the following section of the Waverly:

Conglomerate (coal meas.)

1. Logan Group (of southern Ohio.)
2. Cuyahoga shale.
3. Berea shale.
4. Berea Grit—Waverly sandstone.
5. Bedford shale.
6. Cleveland shale.

This would be adapted to our own view by transposing Nos. 1 and 2, or by intercalating No. 1 somewhere in No. 2.

Let it be observed that, in our opinion, the diversity of opinion as to the affinities of the Waverly Group is very largely due to the vain attempt to regard it as homogeneous and the failure to distinguish the Berea Grit from the sandy upper layers—Logan.

Finally Prof. Hall, in Vol. V, of the Palæontology of New York, seems to withdraw quite fully from his early view of the identity of the Waverly of Ohio with the Chemung of New York, (always comparing our Middle and Upper members—the lower being considered unfossiliferous.) He says:

"A careful examination of those species supposed to have a vertical range from the Chemung group to the Waverly group, has shown that they are allied forms but specifically distinct." He nevertheless admits that the genera are identical with those of the Chemung, only four genera of lamellibranchs being found in the Waverly not also found in the Hamilton or Chemung. The series accessible to Prof. Hall was also very incomplete.

If it should prove that many Chemung forms persisted in Ohio long after the shallowing waters of New York were unfitted for them and that forms of carboniferous habit were gradually introduced it would only furnish another to the long list of similar instances standing to the credit of evolution.

For an extended and very valuable discussion of the age of these rocks, see Winchell's papers in Proc. Philos. Soc. Vols. XI and XII, 1870.

That the series of freestones and shales with occasional interspersed bands of conglomerate which occupies a belt of 250–500 feet below the coal measures is really homogeneous may have been doubted, but it is left for the present occasion to point out the nature of the variations in the fauna. The stratigraphy of the Waverly as seen in central Ohio may now be confidently regarded as correctly determined in at least its general contours. The interest attaching to the Waverly group as affording a transition from Devonian to carboniferous faunæ under peculiar conditions will naturally be greatly enhanced if within its own limits transitional forms or facies can be discovered. To gather facts instructive upon this point it is necessary, first of all, to identify continuous and unmistakable horizons. To this end we first directed attention, and found such reference lines in two narrow bands of conglomerate separated by an interval of from 38 to 50 feet, which includes the quarry rock or freestone employed in this county.

Though the conglomerates may disappear or vary, the fauna of the subjacent shales afford conclusive criteria for ascertaining at least their approximate position. With these two lines of reference once established, and leveled east and west through our district, the study of higher and lower horizons became more fruitful.

Before discussing the work in this field it becomes necessary to recall some points already stated in the first paper. It will be remembered that our attention was given solely to a thin band of shale lying about 160 feet above the bottom of the coal-measures at Flint Ridge. In the same report a band of limestone is referred to as occupying a place about 100 feet above the Maxville limestone, in Muskingum county and conjecturally referred to the position of the lowest coal seam east of Newark, at Bald Hill. This limestone has been further examined, and although it has not yet been found possible to satisfactorily demonstrate our position, the palæontological evidence is not inconsistent with that theory. West of Fultonham this thin band is well exposed and lies about 120 feet below the coal mines of that region. If these coal mines are on the same horizon as that at Flint Ridge, the relation is the same as at that place, except that a few feet are interpolated (as would be expected) above and below. The limestone in question is sometimes dark and shaly, at others is dense and crystalline. Its fauna is quite large and the following species have been identified.

1. *Productus cora*, rare, though common as at Flint Ridge.
2. *Productus semircticulatus*, common.
3. *Productus longispinus*, not common.
4. *Chonetes mesoloba*, rare.
5. *Athyris subtilita*; common.
6. *Spirifer cameratus*, (= S. striatus.)
7. *Allorisma subcuneata*.
8. *Naticopsis nodosa*.
9. *Naticopsis nana?*
10. *Macrocheilus ponderosus?*
11. *Macrocheilus planus?*
12. *Macrocheilus paludinæformis*, small form.
13. *Macrocheilus fusiformis?*
14. *Bellerophon nodocarinatus*, fine large specimens.
14. *Bellerophon* sp.

The fifteen species discriminated are beyond doubt coal-measure forms and the chief difference between the assemblage and that at

Flint Ridge is in the relative abundance of the species. Naticopsis nodosa has not been recognized from the Flint Ridge shales and Productus semireticulatus is abundant in the Waverly, but rare in the Flint Ridge shales. It is possible, but not probable, that the two horizons are identical. The sandstone and shales underlying this band are unfossiliferous and the next link in the series connecting the coal-measures and the Waverly is found in the so-called Maxville or Chester limestone. A considerable fauna will yet be restored to us by a sufficiently prolonged search in the limestones and shales of this series in Ohio, which is nearly 25 feet thick in the vicinity of Fultonham. Eleven species have been described from this horizon by Whitfield. The characteristic species which are everywhere abundant are *Productus parvus*, which, however, is often much larger than the type and approaches P. semireticulatus in some characters, *Spirifer glaber*, *Athyris subtilita*, *Euomphalus planodorsatus* and *Bellerophon* sp. *Pleurotomaria chesterensis?* *Holopea newtonensis?* *Naulilus spectabilus*, *Ctenodonta?* sp. *Allorisma andrewsi.* (Plate XIII, Fig. 12) and *Spirifer increbescens*, H. With regard to the last mentioned species it may be here noted that no difficulty exists in tracing this species to its successor in the coal-measures (S. opimus) and to its probable progenitor in the St. Louis group (S. Keokuk var. Hall), this in turn to the Keokuk group. There are many hints of this sort which will occur to the attentive student of these successive faunæ. A cup coral, Lophophyllum sp? (See Plate XIII, Fig. 17), also occurs rarely.

In this connection may be described

Nautilus (?) bisulcatus, sp. n.

(Plate XI, Fig. 16.)

Shell of moderate size, very compressed rotate, volutions not embracing, (two to three?) transverse diameter of outer volution less than one-half the dorso-ventral diameter, transverse diameter greatest one-third from the ventral side; upper and lower surfaces marked dorsally by a carina within which is a broad, shallow grove, followed by a second ridge about one-third from the dorsal margin, succeeded by a groove shallower than the first, which is followed by a gently convex portion extending to one-fifth from the ventral margin, where is a slight carina, beyond which the surface inclines to meet the similar plane of

the opposite side at an acute angle, the resulting surface being slightly concave.

Our specimens are fragments which do not furnish material for careful description. The symmetrical relation of the two sides indicates a cephalopod in spite of the apparent absence of septa. The siphuncle seems to be central. The greatest diameter was not less than 75 mm; dorso-ventral diameter of volution near end, 15 mm; lateral diameter of volution, 6 mm; the width of the plane dorsal margin is 3 mm *N. pauper*, Whitfield may prove identical with our form, but it would not be suspected except from incidental similarities and the fact that our form is derived from the same horizon at Fultonham.

West of Fultonham, two or three miles, are exposures which permit the reconstruction of the following section:

Coal measure sandstone (exposed)	10 ft.
Bituminous shale	3½ ft.
Limestone	18 in.
Shale (many fossils)	2½ ft.
Sandy layer	5-6 ft.
Firm limestone	6-10 ft.
Shale	3-6 ft.
Reddish and grey silicious shale and free-stone—Waverly (exposed)	10 ft.

The section not being continuous may not be very accurate, but expresses the approximate relations. No inconformity could be detected between the shales forming here the base of the coal-measures and the reddish layers, which are undoubtedly Waverly and contain *Chonetes illinoisensis* and other characteristic fossils.

The Waverly layers for some distance below the coal-measures are, except in a band about 4 feet from the top, apparently unfossiliferous. About two and one half miles east of Rushville is exposed about 20 feet of Waverly, which lies about 70 feet below the top of the Chester (Maxville) and hence, if that series has there its maximum development, some 50–60 feet below its base. This exposure is interesting on account of the presence in it of a Trilobite (*Phillipsia meramecensis*) not found in the lower beds of the Waverly and having a

decided carboniferous habitus. At Rusville the following section is exposed:

Shale, with Productus semireticulatus and Spirifer striatiformis	100 ft. above congl. II.
Shales and thin bands of freestone (Pleurotomaria, etc.)	30 ft.
Nodules of lime (fossiliferous)	65 ft. above congl. II.
Shales.	
Freestone, 40 feet above congl. II. Nautilus sp., Hemipronites, Productus arcuatus, etc	about 10 ft.
Shales	about 30 ft.
Conglomerate and sandy freestone	5 ft.

"Conglomerate II" forms the basal, 18 inches or so, and here is not very coarse.

Shales, with Allorisma winchelli, Prothyris meeki, Sanguinolites obliquus, Grammysia ventricosa, and Pholadella newberryi.

This last is the lowest horizon seen in this part of the state and corresponds to the shales overlying the freestone in Licking county. The fauna found at the highest horizon of Waverly in Licking county, is here encountered here near the top and the various species can be allotted to their position in the series with unexpected ease and certainty.

The little excursion thus made into Muskingum and Perry counties enables us to complete the series in its normal condition. However, the moment we turn our attention to our allotted task in Licking county, we discover that the series is imperfect at one point. While conformity between the upper Waverly and lower Chester does not exclude the idea of a considerable interval of time between the fossiliferous bands of the two groups, it is apparent that in Licking county the Chester interval is unrepresented and that much of the upper Waverly is generally absent, so that the white sandstone or conglomerate of the coal-measures lies unconformably on one or other of the Waverly beds and the upper surface of the Waverly itself has obviously suffered erosion. The amount of the erosion varied in different places and where greatest is covered by coarse quartz pebbles of granitic origin mingled with coal measure trees of large size. The suggestion of extensive erosion been heretofore made, but absolute proof has been wanting. It is has our privilege to complete the evidence and to point out in general the amount of loss thus incurred. It has been quite generally supposed

that an elevation of the coast at the close of the Waverly period caused the recession of the water, and that the period occupied at the west by the deposition of some 550 feet of sediments was not a time of rock formation in central Ohio. The results of close study of the lowest coal-measure conglomerate has unexpectedly indicated the contrary. While engaged in collecting samples of the quartz pebbles forming the bulk of this conglomerate eight miles northeast of Newark, a large number of fragments of limestone were also broken out.* These are angular and. though very badly decomposed, show that they could not have been derived from a distance, as the quartz must have been in order to free itself so fully of the softer, including country rock, and acquire its rounded form, and, moreover, they contained a few fossils which can only be referred to the age of the Chester or St. Louis Group. These conglomerates are full of the impressions of Lepidodendrids and Calamites and seem to have been torn from their places by torrents which carried from the mountains to the north their freight of coarser and finer material, much of it being of a metamorphic and igneous nature. The Chester limestone must at that time have been more or less firmly consolidated, perhaps in the form of clods of limy clay, and has preserved identifiable remains to tell the story. Thus the same coarse conglomerate tells us that a mighty river flowed into the coal-measure ocean from a region to the north, exposing igneous and metamorphic (partly granitic) rock, that it flowed through a region covered by deposits of St. Louis or Chester age, thus showing that a large series supposed to be absent in this part of the state was simply obliterated by erosion. Such a chain of argument indicates what possibilities are open to a more careful study of limited areas. The fossils referred to are figured beyond, in connection with those of the Chester further south.

We now pass to the Waverly proper. This may be divided into three well-marked groups which present us with a carboniferous, a Waverly, and a Devonian facies respectively. The lower division ought probably to be referred uncompromisingly to the Devonian, the second, less obviously Devonian, still contains a fair proportion of Chemung fossils, while the upper series can be unhesitatingly called sub-carboniferous. These zones are marked off, as already hinted, by

*The Ohio geologists have observed the same fact in other parts of the state, but a different interpretation has been offered.

two bands of conglomerate, which include between them the middle member or Waverly proper.

The upper Waverly, with its 100–150 feet, has been rather less studied than either of the other divisions. Near the top it is characterized by *Productus semireticulatus*, *Spirifer stratiformis*, *Phillipsia meramecensis*, *Nautilus* sp, *Crenipecten*, sp. n. *Hemipronites* is also very abundant.

The upper conglomerate, or congl. II. is itself often fossiliferous with the species characteristic of the shale below and especially *Spirifer winchelli*. *Allorisma winchelli*, *A. ventricosa*, *Sanguinolites obliquus*, *Prothyrus meeki*, *Edmondia*, etc., are the determinative forms for the shale. The free-stone which lies below this shale is full of fossils. *Spirifer carteri*, *Crenipecten winchelli*, *Phillipsia shumardi*, *Rhynchonella cooperi* and *R. contracta* are characteristic of this zone. After an interval of shale, sometimes with *Allorisma winchelli*, but generally barren, we reach congl. II, which varies from a narrow belt of sandy free-stone to 10 feet of coarse sand and conglomerate. A few feet below this is one of the most characteristic layers of the whole formation, abounding in *Palæoneilo concentrica*, and *P. attenuata*, *Sanguinolites unioniformis*, *Streblopteria media*, *Bellerophon lineatus*, *B. galericulatus*, etc., etc. The same fauna may be found for 30 feet below, but 40-50 feet below is a zone with quite a different habitus, containing *Rynchonella sappho*, *Leiopteria ortoni*, *Crenipecten tumidus*.

Near the same horizon, probably below it, but exposed further west and not yet certainly located vertically, is a zone with *Spirifer marionensis*, which species is also abundant in limestone nodules some 15–20 feet lower along with a peculiar fauna of considerable individuality, at Moot's run.

Through the kindness of Mr. E. S. Clarke, a system of levels was run from Granville to exposures eastward from Newark, correcting the barometric work of last year. The conglomerate I. being the most available base line, the levels refer to the top of this stratum, which is exposed along "the avenue" leading to the buildings of Denison University. Along a line bearing S. 68° E., for 3.85 miles, this conglomerate dips 79.35 feet, from this point to the south Newark quarry, a distance of 4.44 miles S. 79° E. the dip is 48.74 ft. A portion of the difference in inclination is due to the increased thickness of the conglomerate to the eastward, but the influence of the Clay Lick arch is also beginning to be felt. In our last report the mistake was made

of paralellizing the conglomerate I. at the Dug-way, (or the first of the above mentioned stations) with the second conglomerate at the south Newark quarry, thus making the combined Waverly section too small by 39 feet. In like manner a level (barometric) between Granville and Cat run, a distance nearly due north of 5½ miles, reveals a dip to the south along congl. I. of 79 feet, or over 14 feet per mile. The section at this place is

4. Freestone and part of shale below congl. I. ..... 35 ft.
3. Shales and freestone ..... 29 ft.
2. Congl. I, coarse pebbles, loose ..... 16 in,
1. Shales with Palæoneilo attenuata ..... 14 ft.

The relations are almost precisely as at the Dug-way. Passing southwest from Granville, a distance of three miles, at Cheney's run, we find, at the bottom, a fossiliferous band marking the horizon 40 ft. below conglomerate I. This is about 30 feet higher than at Granville, a dip of only 10 feet per mile. Now passing due west to a point 4½ miles west of Granville, the bridge over Moot's run is reached. At this place a fossiliferous layer of shale is found 36 feet higher than the last mentioned, which would permit this horizon to be identified with the 40 ft. layer above mentioned assuming a dip of 12 feet per mile to the east. There are, however, at this place indications of a local increase in dip, and this layer contains *Spirifer marionensis* and few fossils identified in the 40 ft. layer farther east, while 20 feet above are layers with the lithological character of that horizon (unfortunately unfossiliferous.) At the foot of this exposure, 20 feet below the *Sp. marionensis* layer, are found specimens of *Chonetes logani* and *Rhynchonella sappho.* Passing one mile west, a very interesting bed of shale with limestone nodules is exposed. This bed is very fossiliferous and is the lowest richly fossiliferous bed known in the Waverly. This is thirty feet above the Spirifer marionensis layer and, allowing a dip of 15 feet to the mile, would still lie at least 15 feet above that horizon stratigraphically. It probably is upon nearly the same horizon Continuing west twelve miles to Rocky fork, a series of gritty flags and shales is reached about 15 feet higher than at the *Sp. marionensis* layer at Moot's run, by barometer; thus, allowing a dip of 14 feet per mile, we reach a horizon about 170 feet below that layer. At a point three or four miles farther west and south, not far from Gahanna, these gritty layers are quarried and are interspersed with layers of bituminous shale like the Ohio black shale. A point quite near the foot of the Waver-

ly is here reached 120 feet below the last mentioned zone. As the southern element in the dip is here quite appreciable, it would be an ample allowance to estimate this horizon at 150 feet below the last named, or 320 feet below the lowest fossiliferous zone of the Waverly. Near Summit on the Baltimore and Ohio R. R., we find the following section:

6.	Shaly freestone	10-15 ft.
5.	Blue shale	4 ft.
4.	Grey calcarous sandstones	12 in.
3.	Blue shale	10 ft.
2.	Unexposed	70 ft.
1.	Black "Ohio" shale	30 ft.

The entire unfossiliferous part of the Waverly may therefore be estimated at less than 350 feet, and the Waverly series in Licking Co. at less than 570 feet. Probably 550 feet would about cover it.

A generalized section of the Waverly in Licking Co. is as follows:

Carboniferous conglomerate.

14.	Upper Waverly, shales and flags with few fossils. Phillipsia meramacensis, Productus arcuatus, Prod. semireticulatus, Aviculopecten sp., etc	about 100 ft.

Best exposed at Bald Hill and 1 mile north of Newark.

13.	Shales, soft, with few small fossils	4 ft
12.	Conglomerate II. Spirifer Winchelli	18 in.
11.	Shale, "Allorisma layer," Spirophyton	7 ft.
10.	Freestone (Berea?) many fossils	30 ft.
9.	Shales, barren	15 ft.
8.	Conglomerate I	1–4 ft.
7.	Shale "Lamellibranch layer"	4 ft.
6.	Shales, same fauna, less prolific	26 ft.
	Flags	12 in.
5.	Shales, barren	10 ft.
4.	Flags, with Rhynchonella sappho, Leiopteria ortoni, Strebloteria media, etc	18 in.
3.	Shales, barren	20 ft.
2.	Shales, with Spirifer marionensis	18 in.
1.	Shales, barren, Flags and black bituminous shale	about 350 ft.

Black shale.

All below congl. I. is spoken of as division I, Ia being that portion of this division over 40 feet below this zone, Ib the upper 40 feet. Division II includes all between congl. I and II, and division III, the remainder.

In our study all collections made before the discrimination of these various horizons were abandoned and the whole recollected, labeling each fossil with its relative position with reference to the base line. The typical exposure of the county is that formed by the erosion of Raccoon creek, near what is known as the "Dug-way," between Granville and Newark. It is supplemented by that one mile south of Newark and one mile north of the same place. Exposures six miles further east corroborate the observed sequence. The lower layers can be best studied at Moot's run, four miles west of Granville.

The most significant determinative fossils are Allorisma winchelli, of the shale below congl. II; Spirifer winchelli, of congl. II; Spirifer cuspidatus, of division II; Palæoneilo attenuata, of shales below congl. I; Leiopteria ortoni of the 40 ft. layer below; Spirifer marionensis, of still lower horizons. The discussion of the stratigraphical relations of the various species is omitted and the reader is referred to the distributional table at the close.

Outside of Licking county considerable work has been done which is here only so far employed as to verify the observed relations. It is reserved for another occasion when a wider range of comparison may be admissible.

LIST OF FOSSILS FROM LICKING COUNTY, OHIO.

This list has been compiled under almost disheartening difficulties and is merely a preliminary contribution to the fauna of the group. Certain subkingdoms have not been studied at all and as the plates were engraved prior to the elaboration of some families typical forms have not always been figured. The collection of additional specimens may affect determinations here made, but it is not believed that further study will materially alter the relative value of the chronological evidence. I wish here to express obligations to Prof. Alexander Winchell, the renowned geologist of Michigan, for indispensible assistance. A small suite of specimens and part of the plates were placed in his hands, which he kindly examined and reported upon, thus preventing serious mistakes. However, it is but just to say that the nature of the material sent was such that, even where his views are quoted, it would be unfair to implicate him in the mistakes contained in this paper for which the writer assumes full responsility, at the same time acknowledging himself indebted very largely for whatever value the paper

may have to the disinterested generosity of his distinguished friend. Equally indispensible has been the work of friendly collectors, Mr. W. F. Cooper having assisted most largely, while Messrs. C. J. Herrick, Ira Crawford, E. S. Clarke, J. L. Deming, and many other students and friends have similarly assisted.

The tabular review is intended to exhibit at a glance the general stratigraphical conditions as well as certain comparisons bearing on the age of the group. It will be constantly remembered that only a part of the species collected are described in this number.

I. signifies all below conglomerate I, as seen at the foot of the south Newark quarries; II. is that section including the freestone at Newark and ending with conglomerate II, 50 feet above the base of the quarries at Newark; III. is the remainder of the series including shales and flags to the base of the Chester or coal-measure conglomerate as the case may be.

Phillipsia meramecensis, Shumard.

(Plate XI, Fig. 3.)

A single pigidium from near the top of the Waverly east of Rushville.

Pigidium considerably wider than long, parabolic in outline, with a very narrow border; axial lobe broad and high, fully ⅓ as wide as the pigidium proximally, composed of thirteen narrow, unsculptured segments, prominently truncate behind, separated from the pleuræ by a not very deeply impressed sulcus, but rising above them almost at once; pleuræ rather convex, eight segments being evident, which are low and flat, with a slight groove on the top of the first and second near the posterior edge; the narrow border of uniform width and abruptly deflected. Length 8 mm; width 11 mm; width of axial lobe 7 mm.

The figures given by Shumard do not show the characters emphasised in his description, which agrees quite fully with our specimen. The species was originaly found in the Archimedes limestone at Fenton, St. Louis Co., Missouri, a horizon, apparently the equivalent of the one here noted.

Phillipsia shumardi. Herrick.

(Plate II, Fig. 22.)

Proetus missouriensis, SHUMARD. Geol. Missouri.

Abundant in the freestone of middle Waverly. See Bul. Den. Univ. Vol. II, Part I, page 69.

Phillipsia praecursor, sp. n.

(Plate XII, Fig. 1.)

Closely related with P. shumardi, Her.

Head shield parabolic in outline, axial portion very high, rapidly curved, highest portion near the centre of the glabella. Glabella nearly twice as long as wide, anteriorly forming a high, rounded, finely striate ridge, separated from the axial elevated portion by a deep but narrow sulcus; postero-lateral lobes small, oblique, well defined by the arched grooves which reach the cervical groove or nearly so, and separated from each other by an interval equal to their own width; there is but a single pair of secondary on lateral lobes with a pretty well defined sulcus lying well back of the centre; palbebral lobes large, quadrate; cervical suture deep and wide, cervical segment rather large. The cheeks are bordered by a triangularly elevated margin and a rather deep groove and project backward into short, acute spines. None of our specimens show the fixed cheeks and the figure of the head is imperfect in this respect, but bears a strong resemblance to P. gemmulifera. Pigidium nearly semicular, moderately elevated, about 1½ times as wide as long, the axial portion is high, tumidly conical, and obtuse, marginal sulci rather deep; axis composed of nine (ten) segments separated by deep grooves, pleural portions rather regularly convex, with about seven apparent ribs which are elevated and pustulose dorsally and bifurcate near the margin; margin convex, separated by a shallow groove. All of the annuli as well as the median parts of the gebella, are covered with well defined pustules. Length of glabella 14 mm; width 7 mm. or more; length of pigidium 11 mm; width 17 mm.

This form is obviously very nearly allied to P. elliptica from the

Kinderhook of Ill. and P. swallovi, from the Chouteau limestone of Missouri, but seems quite distinct.

From nodules in shale at Moot's run, also in the shales containing the same.

Pleurodictyum Problematicum, Goldf.

(Plate VIII, Fig. 15.)

"Corallum depressed, sub-hemispherical, or semilenticular; the under side concave and provided with an epitheca, the upper convex. Corallites somewhat irregular in size and form, more or less angular, often hexagonal, short, increasing rapidly in size and so distinctly radiating from the middle upwards and outwards, that those of the lower series lie nearly or quite parallel to the concave base, and even decline as they extend out from near the middle to the periphery—those rising from near the middle shorter than the others; connecting pores as indicated by their casts, rather numerous, and apparently irregularly arranged, sometimes passing through the corners as well as the sides of the walls between the corallites."

A considerable number of this interesting compound coral were found by W. F. Cooper, in the upper layers of freestone near congl. II, in a condition similar to that described by Meek and Worthen. The "coarse, friable sandstone," referred to the Onondaga section of the corniferous group by the Illinois geologists seems to belong at a higher horizon as first supposed, at least the presence of the same form in the Waverly group, pretty well up in the series, lends probability to this suggestion.

Orbiculoidea sp?

(Plate VIII, Fig. 14.)

A large species of Discina-like appearance is common in the shales of the middle Waverly and has been usually referred to D. newberryi, Meek. As only the dorsal valve is known and this is larger than the type, we prefer to defer identification. There is a ridge rather than a slit, as in Discina and the shell is usually distorted.

Crania hamiltoniae, H. (?)

(Plate XII, Fig. 10.)

This little species is found adhering to mollusks and brachiopod shells and is largely modified by the ornamentation of its host. Our specimen agrees as fully as might be expected with the smaller varieties of the species quoted.

Broadly oval or sub-circular; dorsal valve sub-conical; apex subcentral or excentric, pointed, surface marked by very fine (scarcely lamellose) striæ. Lower valve not seen. Concretionary layers at Moot's run—lowest fossiliferous horizon.

This species, whether specifically identical with C. hamiltoniæ or not, has a decided Devonian aspect.

Productus Nebrascensis, (?)

(Plates I, Fig. 24; III, 23(?) 23a.)

Specimens having the characters of this species are widely distributed. Though never attaining a very large size there is a considerable range of variation in this respect as well as in outline and form. The rather regular and prominent pustules are sufficiently characteristic. The species is known from the horizon of congl. I. to the top, but may descend lower.

Productus semireticulatus.

(Plates I, Fig. 26; III, 24; VII, Fig. 11; X, 6, 6a.)

This widely distributed species is especially characteristic of the uppermost Waverly, as found at the tank north of Newark and in the freestone. The species attains a large size and may be recognized by the great prominence of the ventral valve near the strongly incurved beak.

Productus arcuatus, Hall.

(Plate III, Fig. 18.)

Prof. Hall's description runs as follows:

"Ventral valve much elevated, longer than wide, very gibbous,

extremely arcuate, the beak recurved upon itself so that the hinge line is nearly opposite the centre of the back of the shell; hinge line shorter than the width of the shell; cardinal extremities produced into small angular ears. Surface marked by strong radiating costæ, which bifurcate upon the umbo and below, and sometimes coalesce toward the base of the shell; entire surface covered by fine undulating concentric striæ, and, in the upper part, a few strong wrinkles, which are conspicuous on the ears and umbo. A few marks of the bases of spines are noticed, but they appear to have been irregularly distributed."

This species is P. semireticulatus in miniature. Our specimens differ from Hall's figures chiefly in the greater irregularity of the striæ, in this respect, however, agreeing with his description.

Length 17 mm; width about 15 mm; hinge 14 mm. Near congl. II, Granville and Newark.

Productus flemingi, var. burlingtonensis. H.

(Plate III, Fig. 20 [and 22?])

A few specimens, apparently from the upper division of the Waverly, resemble very closely this species. The occurrence of a Burlington species in this horizon is certainly suggestive.

Productus (Productella) shumardianus, H.

Plate VII, Fig. 18; Plate VI, Fig 16?)

(= Productus subaculeatus, Murch.)

Productus subaculeatus, has been identified by Hall, from the Corniferous. He says:

"I have been unable to identify it with any species in the Hamilton and Chemung groups of New York, though the resembling those which I have placed under P. shumardiana. A larger collection of specimens may possibly show a passage from one to the other."

Productus shumardianus is doubtless identical with *P. spinulicostus*, H., *P. concentricus*, H: and *P. pyxidata*, H., while *P. lachrymosa* is perhaps less closely allied, though a member of the same series.

Productus dolorosus, Win., is apparently a synonym for *P. truncatus*, H., and has not yet been certainly identified within our limits.

Typical ventral valves of P. shumardianus are frequent in the sandy parts of conglomerate I, though never found much above this horizon. A dorsal valve apparently of this species was found in the nodules at the foot of the exposure at Moot's run, at least 50 feet below the horizon of conglomerate I. I quote Hall's description.

"Shell concavo-convex, sub-hemispherical, wider than long; hinge-line nearly or quite equalling and sometimes greater than the shell below. Ventral valve very convex, gibbous in the middle and on the umbo, which is abruptly narrowed toward the beak, and the apex curved over the hinge line; the sides abruptly depressed toward the cardinal extremities, which are flattened and more or less auriculate. In one specimen observed, the apex is minutely truncate, and there is a barely perceptible line at the junction of the two valves, which indicate an area. Dorsal valve concave, often corresponding essentially with the ventral valve, but sometimes nearly flat in the upper and central portions and abruptly deflected toward the margin. Surface of the ventral valve marked by intermittent radiating ridges, gradually rising from the surface and terminating below in elongate spines; while upon the upper part of the shell, about the umbo, there are scarcely perceptible elevations of the surface above the base of the spines. * * * The entire surface is marked by close concentric undulating striæ."

The cardinal process of the dorsal valve is bifurcate. Figs. 6, 6a, 6b and 11, of Plate XII, illustrate various conditions of this species, Fig. 6 especially resembling P. spinulicostatus.

[*Productus concentricus*, H.]

(Plate VI, Fig. 16.)

(= P. shumardiana, H. ?)

The identification of this dorsal valve was suggested by Prof. A. Winchell, but it is made with some hesitation, as the specimen was found associated with P. shumardianus as above indicated. In markings, both concentric and pustulose, the valve agrees better with that species from which it seems to differ somewhat in form. Nodules, foot of exposure at Moot's run.

Productus (Productella) lachrymosus. var. stigmarius, H.

(Plate III, Fig. 28.)

(Cf. P. curtirostra, Win.)

A few specimens, mostly poorly preserved, from the nodules at Moot's run, represent this or a closely allied species. The specimen figured shows only the cast of the dorsal valve. The fine, wavy concentric striæ and interrupted radiating ridges, and slight mesial sinus can all be duplicated in New York specimens.

A large ventral valve measures 40 mm. in width, 30 mm. in height, and about 18 mm. in convexity of valve. There is a faint but obvious sinus and the surface is marked by nearly obsolete coarse ribs, as well as the fine, irregular concentric striæ. Prof. Hall suspected that this large form would prove distinct from P. lachrymosus, in which we concur.

Productus (Productella) speciosus, H. ?)

Specimens more nearly agreeing with the Chemung species than those with which it is associated, have been secured. These specimens are characterized by numerous, rather regularly arranged, small pustules covering the entire surface. Moot's run, calcareous nodules.

Productus gracilis, Win.

(Plate VII, Fig. 20.) No. 1347.

The original description reads as follows:

"Shell small, aperture of the ventral valve forming a little more than a simicircle. Ventral valve moderately inflated for a Productus, with flattened, smooth, triangular auriculations; hinge-line equal to greatest width of shell; mesial sinus wanting or barely perceptible; external surface marked by fine, rigid, sharp, once dichotomizing radial striæ, numbering about 40. No indications of spines have been detected. Length of hinge-line .29 in., length from beak to anterior margin, .21."

Our form is nearly as large again and has the hinge-line shorter

than the length of the valve, nevertheless we dislike to attempt to distinguish it from a species confessedly founded on a single imperfect ventral valve. Our specimen, however, has no spines and a compound dischotomy of the striæ. Sandy layers of congl. I, "Dugway," near Granville.

Chonetes logani, Nor. and Pratt.

(Plate VII, Fig. 22; Plate III, Fig. 12?)

In Fig. 22, Plate VII, the radiating costæ are not distinct enough, while the specimen figured on Plate III may prove to be C. multicosta, Win. C. logani seems to be distributed throughout the series up to congl. II, at least.

The confusion introduced into this genus by identifying this species with C. illinoisensis, has been corrected by Prof. Winchell.

Chonetes illinoisensis, Worthen.

(Plate III, Fig. 21.)

Rather large for the genus, transversely semioval; moderately convex ventrally; length between two-thirds and three-fourths the width; hinge line nearly equal to greatest width, with five or six small oblique spines on either side of the inconspicuous beak; ears somewhat flattened; nearly rectangular; front margin a broad curve; surface of ventral valve rather evenly convex, highest near the middle, casts showing a strong mesial septum; dorsal valve gently concave, with distinct cardinal fleet. Surface ornamented with about 100 bifurcating, thread-like striæ. Length 7 mm; width 11 mm. Our specimens rarely attain the size of the western ones, though often much larger than the above measurements.

Found in the sandy rock above congl. I; also forty feet or more below this horizon at Moot's run. The spines of this species are much more slender and curved than in *S. scitula*.

Chonetes scitula. Hall.

(Plate I, Fig. 4.) No. 1397.

Shell small, semi-oval, hinge-line about equal to greatest width, tumid along the medial line. Ventral valve, moderately convex along a line from the beak to the front margin, about one-third the entire width, thus elevated near the front, lateral margins depressed; beak slightly prominent, hinge-line somewhat angled, armed at either extremity with at least two spines. Surface marked by fine but rather prominent, distant striæ which do not bifurcate, sometimes somewhat alternate. Width about 8 mm, height 5 mm. Dorsal valve nearly plane. Near the base of the series at Moot's run, probably 50-60 feet below congl. I.

Our specimens agree even to details of hinge structure with those of New York. The spines are strong and oblique.

Another form found near congl. II, or about 80 feet above the present species, resembles this in form, but has more numerous bifurcating striæ. This we compared with *C. setigera*, H., but though closely agreeing otherwise, our species has oblique spines on the hinge.

Chonetes tumidus, sp. n.

(Plate II, Fig. 21.)

Shell of medium size. closely resembling C. acutiradiata of the Corniferous group of New York.

Ventral valve very convex (as much so as C. hemispherica of the Upper Helderberg), hinge extended, with mucronate extremities, straight, apparently with few oblique spines; body of the shell nearly semi-circular, forming nearly a segment of a sphere, being suddenly depressed to the flat ears, which are acutely triangular. Umbo somewhat prominent. Surface marked by numerous (50), regular, nearly continuous, rounded striæ, which rarely bifurcate. Exfoliated specimens show numerous oval pores between the striæ. Dorsal valve not known. This very pretty species is found in the irregular calcareous nodules at base of the section at Moot's run and adds a significant Devonian color to the facies. The resemblance to C. hemispherica is close, but the outline is as in C. acutiradiata, H.

Width 12 mm, height 7 mm.

Chonetes pulchella, Win.

(Plate III, Fig. 14.)

"Shell small, semi-circular; hinge almost equalling the greatest width, rectangular at the extremeties, furnished with two or three stout hollow spines on each side of the beak, one projecting from the hinge extremity, and diverging at an angle of about 22° with the hinge-line —the second half way to the beak and diverging at an angle of 45°, each of these spines having a length equal to half the hinge line. Ventral valve, exclusive of the flattened hinge angles, spherically convex; internal median ridge extending to the middle of the valve. Surface with about 54 feeble, rounded ribs, often nearly obsolete on the hinge angles; these are crossed by numerous microscopic, concentric striæ; the grooves beneath the ribs are acute and bear a few spinous projections near the shell margin. Dorsal valve nearly flat, generally a little concave near the margin, marked, like its fellow, with radiating lines, and often a few concentric folds. Area very narrow, equally excavated in both valves."

Our specimens are 7 mm. wide and about 5 mm. long. Kindly identified by Prof. Winchell. Specimens believed to have come from the free-stone of middle Waverly, Granville, O.

Hemipronites crenistria, Phil.

(Plates V, Fig. 14; III, 24; Plate VI, Fig. 8; Plate IX, Fig. 21.)

The great variability of the American members of Hemipronites makes any attempt to restrict the limits of species very difficult—for us, impossible. The figures indicate the extremes of the series abundant in the middle Waverly.

This widely distributed species occurs in all the strata containing numerous fossils. The largest specimens seen come from the same horizon as Spirifer marionensis, probably 60 feet below congl. I, though these are less than half the size of the largest figured by Davidson. (Sup. plate XXXVI.) These are very transverse and the striæ are very fine and frequently irregular. The ventral valve is only moderately convex. (Dorsal valve 58 mm. wide, 30 mm. high) about 13 striæ in 5 mm. (near the margin.) In the shale below congl. I, speci-

mens much less transverse and with distinctly alternate striæ occur. In the free-stone this form occurs with *var. cylindrica* (= var. robusta, Hall), which latter, or a still more Orthis-like variety, occurs in congl. II.

Orthis Vanuxemi. Hall, var. pulchellus, var. n.

(Plate V, Fig. 9.) No. 1396.

This beautiful little Orthis occurs in large numbers in a zone near the top or above the top of the quarry rock in Granville, and seems to pass into forms resembling those generally identified with O. michelina. Without discussing the probable relationships of the two forms we may simply notice the close resemblance of our specimens to those described by Prof. Hall, from "calcareous shales of the age of the Hamilton group" in several localities in Illinois, Missouri, Iowa, and New York.

Shell nearly circular or sub-quadrate in outline, depressed, ventral valve generally longer than wide, most convex one-fifth from the beak, flattened, but not sinuous below. Hinge line short; beak rather prominent, protruding, acute; ears depressed, rounded. Surface covered with numerous small, tubular striæ which increase by bifurcation or more rarely implantation, sometimes by division into three, striæ with porforations or oval punctures; surface also marked by concentric striæ and more distant imbricating lines especially near the front margins; about three stria in the space of one millimeter. Foramen with cardinal process; interior of valve with large vascular impression, and mesial process. Dorsal valve nearly circular, convexity above the middle, cast with a broad mesial sulcus from the beak to near the middle. Length of ventral valve 15 mm; width 15 mm.

Orthis michelina, var. burlingtonensis, H., is hardly at all different. In it the perforations upon the striæ are represented as elongate rather than circular, in which point our specimens agree.

More typical specimens of O. michelina also occur in the free-stone.

Rhynconella contracta, H.

(Plate X, Fig. 9.)

We are quite unable to distinguish any differences between a small species with very acute plicæ and that described by Prof. Hall, from the Chemung. Prof. Hall himself made the same identification in 1867, and as the name was applied in 1843, it ranks any other name in vogue for the same shell. The range of individual variation is as great as in that quoted. The species is rare in the free stone of middle Waverly.

In a genus as conservative as this one a greater vertical range of species is to be expected than in many other groups

Rhynchonella subcuneata, H.?

(Plate VII, Fig. 23.)

A small species from just above conglomerate I. has nearly the form of the species quoted. The sandy matrix makes a careful study impossible. Our specimen is smaller and less broad than Hall's types, but it is not easy to point out specific distinctions, the static character of the genus makes the continuance of a species during the interval between the horizon in question and that of the Warsaw possible.

Rhynchonella sageriana, Win.

(Perhaps a variety of R. sappho, H.)

Shell rather gibbous, thickness equal to more than one-third the width, transversely extended; ventral valve broadly oval to slightly pentagonal, with a pointed incurved beak; mesial sinus rather distinct, narrower than one-third the width, extending less than half way to the beak, with three to four strong plicæ; lateral surfaces convex, with five or six plicæ on either side, which rather rounded above; lateral margins nearly straight, meeting the beak at an angle of about 110°; length of lateral margins greater than half the length of the valves, intersecting the evenly-curved ventral margin at a point in

front of the middle; concentric striæ or folds appear near the front; hinge plates sub-parallel, over one-seventh the length of the valves. Length to width about as seven to eight. Width 24 mm, height 20 mm; (21–17; 18–17; 21–18; 18–15; 23–20.)

Dorsal valve more nearly quadrate or sub-circular; beak short and incurved; casts showing a strong median plate within; antero-lateral outline semi-circular, postero lateral angle very obtuse, mesial fold inconspicuous, with four or five plicæ, lateral areas with four to six plicæ. Length to width as 4–5.

The specimens vary in many respects, but in no specimens were the mesial plicæ more than four or five, there being three in the sinus and four on the fold in normal adults. Two varieties exist side by side, differing only in the number of plicæ.

The second agrees very closely with R. sappho in some of its varieties.

This species belongs in the sandy layers or flags about 40 feet below congl. I, where it is abundant. The Granville specimens are said by Prof. Winchell to be typical. This is No. 1313, of our Museum Register and has now for the first time been described in full. Our own belief is that all of the closely allied forms belonging in this section of the genus are conditions of a single species—R. sappho.

Rhynchonella sappho, Hall.

(Plate V, Fig. 1; Plate VII, Fig. 25.)

Of large size, agreeing in outline with *R. sageriana*, but with more numerous plicæ, there being generally five in the sinus and six on either side. It is possible to duplicate the Hamilton forms exactly from our collection.

Found in the free-stone of middle Waverly, and also in free-stones from a horizon 60 feet above congl. II, that is in the upper Waverly.

Some of the varieties of this type resemble R. cooperensis, perfectly.

Rhynchonella marshallensis, Win.

This species is recognized by the ventricose, flattened dorsal valve

with numerous (20–28) rounded plicæ, broad fold with six or seven plicæ, and the sudden flexture of the front and lateral margins. The species ranges through the middle Waverly.

Several other species could be recognized, but it is feared that a larger collection would obliterate the distinctions assumed.

Atrypa reticularis, ? ?

(Plate III, Fig. 11.)

Small specimens resembling this species have been obtained from the upper free-stone, lower part of division III. The identification is doubtful, though undoubted specimens said to have been derived from the Waverly are in the museum of Ohio State University.

Genus Syringothyris, Winchell.

(*Syringothyris cuspidatus*, Martin

(Plate I, Fig. 7, (?); Plate II, Fig. 17; Plate V, Figs. 4–7.)

Anomites cuspidatus, Martin, 1796.
Spirifer cuspidatus, Sowerby, 1809.
Davidson, 1857.
Cyrtia simplex, McCoy, 1884.
Cyrtia cuspidata, McCoy, 1855.
Spirifer capax, Hall, 1858.
Spirifer carteri, Hall, 1857.
Syringothyris typa, Winchell, 1863
Spirifer textus, Hall, 1857.
Spirifer hannibalensis, Swallow. (?)

It seems to me after a careful collation of the descriptions above quoted and the comparison of several hundred specimens that a due conservatism will unite all the supposed species and identify them, as positively done by Davidson and Dekoninck, the most careful Euro-

pean authors, with S. cuspidatus. The wide range of variation and distribution make this an exceedingly valuable species for approximately synchronizing widely distant horizons, for its vertical range is not extraordinary. The subjoined table of measurements and data will serve our present purpose in connection with the figures. In the view here indicated Prof. Winchell does not concur, as may be gathered from the extract from a private letter of Jan. 9th, 1888, from which I take the liberty to quote.

"I have heretofore identified with this species some specimens from Newark, Ohio, embracing both ventral and dorsal valves. I received some time since, from Prof. Hicks, specimens from Granville, labeled *S Carteri*, among which is a ventral valve resembling forms identified by me with *Syringothyris typus;* but his dorsal valves differ from those of *S. typus* in having the hinge extremities prolonged and pointed; in more rigid costæ and lack of situation in the middle of the anterior margin. They also lack the deep concentric wrinkles of the dorsal valve of *S. typus*. I hence separate these dorsal valves from Granville from *S. typus*, and leave them to represent *S. Carteri*."

Fig. 17, of Plate II, serves to illustrate the usual form of the smaller and more finely striate form called S. carteri, though these often have acuminate angles The difference between such forms and those figured 4–6 Plate V, is completely bridged, nor does it seem possible to exclude the extreme variety drawn in Fig. 7, Plate I.

The species reaches its maximum in the congl. II, but is characteristic of our middle division, beyond which it extends somewhat both above and below.

Spirifers of the S. marionensis group.

This is the most perplexing subdivision of the genus. Four nominal species contend for admission and present characters so concordant as almost to baffle discrimination. These species are *S. striatiformis*, Meek, *S. centronata*, Win., *S. biplicatus*, Hall, and *S. marionensis*, Shumard. All of these have been at some time identified in Ohio. S. striatiformis alone presents such peculiarities as make it easily identified when perfectly preserved. The S. biplicatus described by Meek in the Ohio Palæontology is stated by Winchell to be his S. centronata, thus eliminating a second from the set. The following

tabular arrangement based on the original descriptions will afford the basis for comparison. The following order being preserved:

1. S. striatiformis, 2. S. centronata, 3. S. marionensis, 4. S. biplicatus.

Species.	Hinge.	Lateral extremities.	Ventral beak.	Ventral area.	Foramen.	Ventral sinus.	Dorsal fold.
1	Shorter.	Rectangular	Pointed, curved.	Mod'rate, arched.	Wide	Narrow, deep	Narrow, low.
2	longer.	acute.	"	"		"	"
3	"	"	"			"	"
4	"	"	"	Narrow	Wide	"	"

	Striæ	Striæ on fold.	Striæ on sinus.	Number of striæ on valves.	Surface ornaments.
1	Numerous, small, round, bif're'ting	8	8	56	Minute striæ
2	"	—	3—5	36—40	
3	"	—	3—4	50	
4	"	6		30	

Between S. marionensis and S. centronata it is very hard to discover any point of dissimilarity. In fact we cannot distinguish specimens from the Cuyahoga shale, the locality of S. centronata, from specimens of S. marionensis from near the middle of the lower division of the Waverly in Licking Co.. S. striatiformis is restricted to the upper portion.

Spirifer marionensis, Shumard.

(Plate VI, Figs 2-4; Plate VII, Fig. 11; Plate IX, Fig. 3?)

Cf. *S. centronata*, Win.

Our figures give a good idea of the range of variation exhibited, though in the smaller shells the mucronate extension of the hinge is more marked. On the largest shells there are rarely more than four plicæ on the fold or sinus and the lateral margins are usually quite oblique. This species has been found in the shale near the east end of the bridge crossing Moot's run, four miles west of Granville, and the layer of nodules one mile west. The horizon being supposed to

lie at least sixty feet below congl. I. Shell nearly semi-circular; moderately convex; length 4-3–2½ times the height; valves of nearly equal convexity. Hinge-line considerably extended with acute ears, which are sometimes mucronate. Ventral valve convex with a rather prominent beak and strongly curved striated area; greatest convexity near the beak; lateral portions depressed; sinus narrow, but rather deep; surface marked by 40 rounded plicæ which are dichotomous, and of which about four occupy the sinus, which is triangular in section, especially near the beak. Area moderately narrow and strongly inclined, with a broad triangular area which is striate. Dorsal valve only moderately convex, laterally depressed, most convex above the middle, fold very inconspicuous, scarcely elevated, with two pairs of plicæ produced by bifurcation of the two primary ones. Dichotomy of striæ of both valves very irregular. Surface concentrically striate, sometimes with concentric folds also. Found in the lowest horizon of Licking Co. Its range being 20 feet, so far as observed.

This species was first described from the so-called Chemung of Missouri. Later, Prof. Hall, in his Iowa Report describes specimen from rocks of the Hamilton age, while Prof. Winchell noted its occurrence in Waverly strata, at Sciotoville, O.

The casts show peculiar internal structures which may be of assistance in destinguishing the species.

Spirifer striatiformis, Meek.

(Plate III, Fig. 26; Plate VI, Figs. 6–7.)

Undoubted and typical specimens are found in our upper Waverly, well toward the summit of the series. The illustrations in the third volume of the Ohio Palæontology convey a good idea of this shell. Isolated dorsal valves, however, resemble the shell called in Ohio, S. carteri, and are sometimes so-called. Eight to twelve plicæ occupy the mesial fold. The fine radiating striæ, when preserved, are good specific marks.

Shell of medium size; semi-oval in outline, only moderately convex mesially, rather flat toward the sides; hinge-line equal to greatest width or sometimes less, often slightly mucronate; lateral margins generally making with the hinge-line about a right angle. Ventral valve much more convex than the dorsal; beak strongly incurved;

cardinal area arched, striate parallel to the hinge line, foramen ¼ to 1-5 as wide as the hinge; mesial sinus rather narrow and ill-defined, triangular in section, continuing to the beak; interior with short, diverging dental lamellæ and small rostral cavity. Dorsal valve quite flat, except the rather low, ill-defined, triangular fold; beak projecting beyond the hinge-line; area narrow, striate *at right angles* to hinge-line. Surface of both valves covered by numerous small, low, rounded costæ, which bifurcate somewhat irregularly and are marked by numerous radiating striæ and, less obviously, by concentric striæ as well as the usual lines of growth. (The cancellated appearance spoken of by Meek is rarely observed, while the radiating striations are quite noticeable. Sixty-five to seventy-five costæ are found on a valve of medium size, from eight to fifteen occupying fold and sinus. The typical form is found near the summit of the Waverly, about 100 feet above congl. II, with *Productus semireticulatus*. This layer occurs at at the very top of the exposure at Rushville and cannot be far below the Chester limestone.

In conglomerate I, are found specimens apparently intermediate between the previous species and S. striatiformis, but more convex than either. In the free stone still above is another variety which is with less doubt referred to S. striatiformis. Specimens are figured on Plate VI, Figs. 6, 7. These have a broader sinus and more nearly quadrate form, though short mucronate ears are retained.

If S. centronata is a valid name for the form from Cuyahoga shales the relation between that species and S. marionensis must be left for future study. The close relation of all these to S. disjuncta of the Chemung is noteworthy.

Spirifer biplicatus. Hall.

Not *Spirifer biplicatus*, Meek, O. Pal. Vol II.

But a single dorsal valve has been encountered with the characters of S. biplicatus, indeed, we suspected the validity of the species. It may be confessed that a wider range of observation may invalidate the assumed distinctions. This dorsal valve differs from those of S. striatiformis, with which it is associated, in the greater distinctness of the plicæ, and the depressions bordering the median fold, and by the fact that the plicæ on the fold are so much smaller than those of the rest

of the surface. The surface is also more convex. There are about 28 pliæ, four being on the fold and those of the general surface are simple, while those of the fold dichotomize. This species is smaller than S. striatiformis. Division III, near Newark. W. F. Cooper, collector.

Spirifer winchelli, sp. n.

(Plate V, Fig. 2–3; Plate II, Fig. 16.)

Most nearly resembling S. mesacostalis. Shell transversely elongate, gibbous; width from two to three times the height. Ventral valve quite convex mesially, strongly and evenly arched from the closely incurved and projecting beaks to the lower margin. The area is very narrow; hinge-line usually strongly produced, lateral angles mucronate; surface marked by about 15 rounded plicæ on either side of the deep triangular sinus. (In one case a trace of slight fold in the bottom of the sinus was discovered, but, as all our specimens are casts, these might not usually be preserved if present. Dorsal valve less gibbous: area very narrow, beak minute; surface most convex near the middle; fold high, strongly defined, narrow, marked in the center by a deep groove. Surface ornamented by lamellose concentric lines. The close relationship with S. mesacostalis of the Chemung require no comment. If the strata were adjacent the two would hardly be separated. A considerable number of closely agreeing specimens were found in conglomerate II, at Granville. Named in honor of the distinguished state geologist of Michigan.

Spirifer sp (Cf. *S. raricosta*, Con.)

(Plate I, Fig. 5.)

A small species of Spirifer, resembling Spiriferina somewhat, or more nearly the species quoted above, is represented by the single fragment from an unascertained portion of the Waverly. As the species in question belongs to the corniferous horizon and ours has a greater number of plicæ, it is improbable that they should proue identical.

Spirifer? hirtus, M. and W.?

(Plate III, Fig. 2.)

A single dorsal valve may represent this species. A similar form from the Cuyahoga shale has been referred by collectors to S. setigera, H. The existence of such an Athyris-like form is of interest even though some doubt must prevail as to the specific relations. To the student of evolution the series beginning with the Devonian and including *S. fimbriata*, *S. prœmatura*, *S. pseudolineatus*, *S. setigera*, *S. lineata*, etc. should be interesting.

Cyrtina, sp.

(Plate VIII, Fig. 18.)

A small species is known from a ventral valve found in calcareous nodules at the base of the Licking Co. section at Moot's run, four and one-half miles west of Granville. Height 4 mm; width 5 mm; convexity 2 mm; beak slightly incurved; sinus narrow, rather deep: about seven plicæ on either side. Our form is less elevated than C. acutirostris, Shumard, resembling S. hamiltonensis, but with a narrower sinus.

Spiriferina solidirostris, White.

(Plate II, Figs. 9-11; Plate V, Fig. 13.)

This pretty little shell is common in a layer of free-stone several feet above congl. II, at Newark. All specimens so far collected are very small and are characterized by the high incurved beak of the ventral valve and the regular concentric striæ, which in well preserved specimens cross the few plications. The dorsal valve is rather flat, with a small beak and 7–9 rather large folds separated by deep, but not wide grooves. The median fold is flattened or even channeled above.

Spiriferina depressa, sp. n. (?)

(Plate 10, Fig. 3.)

Shell of large size, valves nearly equally convex, transverse, the hinge-line equal to the greatest width.

Ventral valve wider than high, moderately convex, beak incurved,

not greatly elevated beyond plane of hinge, the extremities of which are met by the lateral outline at about a right angle. Surface marked by about twelve (8–12) sub-equal rather distant plicæ and concentric, irregular ridges, mesial sinus not so well defined and enlarged as usual. Dorsal valve of the same general form, but somewhat less convex and with less prominent beak; median fold, moderate and somewhat flattened, with about five plicæ on either side.

This species is known from a single gathering, but a considerable number of specimens of quite constant characters. It differs from the preceding not only in greater size, but in the much less convexity and projection of the beak and in the more transverse and square-shouldered form.

Height 11 mm ; length 17 mm.

Small specimens have fewer plicæ, but otherwise are similar. From one mile north of "Dug-way," apparently below congl. II.

Genus Terebratula.

Subgenera Cryptonella and Centronella.

The distinctions which separate the genera Cryptonella and Centronella from Terebratula are of such a character as can readily be referred to slight modifications of the structures characteristic of the last named genus. It seems expedient, especially in view of the admitted impossibility of distinguishing these groups without a knowledge of the internal structures, to regard them as subgenera of the large and characteristic genus Terebratula.

Cryptonella eudora, H.

(Plate V, Fig. 10.)

"Shell broadly ovate, rounded in front, apex obtuse. Ventral valve gibbous in the central and upper part, moderately convex in the lower part, and sometimes flattened toward the front; tapering abruptly to the beak, which is obtuse, little extended beyond the opposite valve, slightly incurved, and truncated by a rounded foramen. Dorsal valve depressed-convex, often gibbous in the middle above; beak

incurved into the cavity below the deltidial plates. Surface concentrically striate with crowded lamelliform ridges toward the sides and front."

Length of our largest specimens nearly 30 mm, width 27 mm. Varying greatly in form and size. The casts figured on Plate V give a good idea of the vascular markings.

Freestone of middle Waverly. Typical specimens are from the Chemung of New York.

Centronella julia, Win.

(Plate II, Fig. 5.)

Shell small, lenticular, ovate or somewhat transverse in outline; valve moderately convex, its beak covered by the higher, incurved beak of the more convex ventral valve; area absent. Surface marked by concentric lines of growth and radiating lines (impressed from the interior upon the cast?) Internal characters of the genus.

Many specimens of this species may be found in the freestone overlying shales above congl. II, at Newark and eastward It agrees in external feature perfectly with Prof. Hall's figures of this species. Other forms are illustrated in figures 4 and 8 of Plate II, and may be refered to this genus. As, however, we know nothing of the essential characters we may forbear burdening synonomy with meaningless names.

Athyris ohioensis, Win.

(Plate II, Fig. 1.)

Some doubt attends the identification, on account of the condition of our specimens, but Prof. Winchell was good enough to compare our casts with the types and considers the identification as a probable one.

Athyris lamellosa, Leveil.

(Plate II, Fig. 7.)

The specimens figured are from the layer below congl. I, and we

are at a loss for any sufficient distinctions between our form and the species quoted. A large species of Athyris is also found in the nodules at Moot's run, which apparently differs from the one quoted. The resemblance between the Devonian and carboniferous members of this genus is too close to make a separation easy at present.

The small species Figs. 19, 34, Plate VII, may be an Athyris or an Amphigenia resembling A. elongata. Congl. I. The affinities of Fig. 21 of the same plate are still more obsure.

Aviculopecten perelongatus, sp. n.

Left valve extremely elongate, narrow and quite convex along the longitudinal axis. Height to length of body as 1½ to 1. Body acutely narrowed toward the curved beak, the sides forming an angle of less than sixty degrees. Posterior wing small, triangular, rather acute. Surface marked by very numerous crowded, hair-like, sharp striæ, which bifurcate and increase by intusuception irregularly, also by concentric folds, which are more distinct toward the sides. The wings have less numerous radiating striæ. The convexity of the valve is greatest near the middle and forms almost a fold along the longitudinal axis, sloping regularly to either margin. The umbonal slopes are both concave and rather abrupt.

Such a brief description of a single imperfect valve would not have been offered except that the form is so unlike that of any known species as to make it unmistakable. Perhaps A. dissimilis Fl., as identified by Toula, from Spitzenbergen, approaches it most nearly in outline, though our species is much more elongated. It does not appear possible that the peculiarities can be to any extent due to distortion. Length 24 mm, width 15 mm, posterior ear 5 mm. Number of striæ in one mm, 3 at the lower margin.

Freestone of middle Waverly.

Aviculopecten (granvillensis, sp. n.)

(Plate X, Figs. 8; Plate XII, Fig. 11.)

Cf. Aviculopecten amplus and A. crenistriatus.

An imperfect left valve and fragments of a right valve suggest very close relationship to A. amplus of the Keokuk of Ill.

From this species our left valve differs in the form of the anterior ear, which is less projecting. The posterior ear is broken, but evidently is very slightly defined. The valve is quite flat and is marked by distant, irregular and somewhat alternating striæ. The surface markings are poorly preserved in our cast.

A faint impression of the right valve of apparently the same species closely resembles in ascertainable characters that of A amplus. It is quite flat and almost destitute of markings. The anterior ear is evidently very distinct from the body and separated from it by a deep byssal sinus. The posterior ear is minute and ill-defined. Length of left valve 77 mm; width 81 mm; hinge 53 mm.? Length of right valve 48 mm. This species occurs in some hitherto unidentified horizon evidently of the Freestone of middle or upper Waverly.

In this connection should be mentioned a large species known only from a single fragment secured near the very top of the Waverly (ten feet below coal-measure congl.) 8 miles east of Newark. This fragment (Plate XII, Fig. 21) is nearly as large as the above but, if a left valve, as seems probable, must be very dissimilar in outline. The alternation and irregularity of the striæ are even more pronounced than in the above, but the striæ are apparently higher and are crossed by innumerable very fine concentric striæ. In some respects this form resembles A. crenistriatus.

Aviculopecten cooperi, sp. n.

(Plate XII, Figs. 16–17.)

A beautiful species, found too late for careful study, differs from all others from the Ohio Waverly in its markings. Closely agreeing with A. sub-cardiformis, Her., in outline, but much less convex. Left valve somewhat longer than wide, posterior ear of moderate size, not sharply set off from the body; surface of valve and ear covered by very fine, rather uniform, but irregularly waved striæ, crossing shallow concentric folds; about 4 of the radiating striæ occupy the space of 1 mm; anterior ear not seen. A fragment of what seems to be the right valve of the same species accompanies it. This valve is less convex and is marked only by very fine concentric striæ, except upon the posterior wing, which has the form and markings of that of the left valve; anterior wing long, acute, separated from the body by

a deep byssal sinus and steep umbonal slope. Length of left valve 16 mm; width 15 mm; length of hinge 10–12 mm.

Nodule layer, Moot's run. Collection of W. F. Cooper.

Aviculopecten (Cf. *oweni*, M. and W.)

(Plate III, Fig. 5.)

Shell small, subcircular, lower margin nearly equally curved to points nearly half way to the beak, here suddenly flexed to meet the lateral margins, the anterior one in the left valve being slightly concave, the posterior a little convex; beak prominent; hinge line somewhat less than the width; anterior ear rather large, obtusely angled; posterior ear smaller and more acute and rather less sharply defined; surface quite convex, greatest convexity being about one-third from the beak, ornamented by rather numerous bifurcating and implanted striæ, of which about fifty can be counted on the body of an average shell. Length 10 mm; width 10 mm; length of hinge 8 mm. The difficulty of comparing this species with A. oweni is increased by a doubt as to which valve is figured by Meek and Worthen. The description states "right valve unknown," while the figure is stated to be that of the right valve. If it be a left valve and our own are likewise left valves, the relation of the ears is reversed. Our species is smaller, but otherwise resembles the Illinois form. None of the species quoted by Winchell as from the Waverly and its equivalents, seem to be identical with this, though it may prove the young stage of one of the common ones, perhaps A. winchelli. The horizon is the same as in that species, the free-stone of middle Waverly.

Aviculopecten (*Crenipecten*) *newarkensis*, Win. ?

(Plate III, Fig. 31.)

A single right valve may belong to this species as indicated by its rather narrow form. As Winchell's specimens were all left valves, the identification can only be conjectural. Length 18 mm; width 15 mm. Valve very flat, covered by irregularly alternate, rather filiform striæ. Umbonal slopes about 90° or less.

Crenipecten sub-cardiformis, sp. n

(Plate VII, Figs. 4–5)

Cf. *Aviculopecten caroli*, WINCHELL, 1863, pars. ?

[Wrongly quoted above as C. tumidus.]

We have been caused a great deal of perplexity by this species, which occurs by scores in our collection. It is chiefly restricted to a zone about 40 feet below congl. I. though it ranges upward to a horizon just beneath it in company with streblopteria media. Aviculopecten caroli, Winchell, would not be considered in this connection were it not for the statement made by Prof. Winchell, in 1870, that it was found at Granville, but that the specimens from that locality "were all right valves, and are much flatter than typical specimens of the same valve." On the whole it may be safer to regard our form as a distinct species unless a comparison of types proves this not to be the case. Shell of medium or small size, nearly circular, height and length equal, with well-defined and depressed ears. Left valve very ventricose, hinge slightly shorter than extreme length; lower margin a nearly circular curve intersecting the auricular margin at about two-fifths the distance from the hinge to the lower margin; anterior ear rather large, greatly depressed below the adjacent portion of the body, from which it is separated by a sudden deflection; posterior ear less sharply defined, but nearly equally as large and not separated by a well-defined sinus from the body, depressed; beak high, but incurved and acute, projecting slightly beyond the hinge; greatest convexity near the union of the upper and middle thirds; surface marked by from thirty to forty strong, very irregular, radiating costæ, alternate ones being generally smaller and originating by implantation or, more rarely, bifurcation; these costæ are crossed by fine, close, but irregular concentric striæ, which do not cross the larger costæ, and distant undulations; the anterior ear bears about six costæ, while the posterior ear is nearly smooth, but exhibits more plainly the concentric striæ; rarely two small costæ occupy the space between the larger radiating ribs. The right valve is very flat and nearly without markings; the hinge is longer than or equal to the greatest length and the ears are very large; and nearly equal; the anterior ear is set off by a deep depression from the body and the valve is provided with a deep bys-

sal sinus below the ear; the posterior ear is less sharply defined by the umbonal ridge, but is lower than the plane of the body and its margin passes into that of the valve by a moderate curve. Although both ears are provided with well defined radial and concentric striæ none appear clearly in any of the specimens on the body of the valve. The hinge of the left valve is crenulated as in A. winchelli, which the right valve resembles. The very convex left valve and surface characters serve to distinguish it from other species.

Height 14 mm; length 14 mm; length of hinge 11 mm.

Crenipecten senilis, sp. n.

(Plate III, Fig. 1.)

The limited number of aviculopectenidæ found in the Waverly induces me to propose a name for this species known only from the left valve.

Shell of medium size, nearly circular or elliptical in outline; rather flat. Left valve slightly convex, with a moderately acute depressed beak; anterior wing large, separated from the body by a moderate umbonal ridge, its outline passing into that of the body by a flowing sigmoid curve; posterior ear obsolescent, obtuse, entire posterior outline a gently convex curve slightly straightened near the hinge. Surface marked by large, very irregular, convex, rounded plicæ which increase without regularity by subdivision into a small and large plica or the plicæ are proliferous without sensible diminution of size of the primary one. The anterior ear is similarly plicate and, like the body, is crossed by fine concentric striæ. The plicæ are separated only by a deep, narrow, angular groove. Length 29 mm, width about the same; anterior ear 8 mm.

The single specimen seems to have been derived from the freestone. The peculiar markings serve to distinguish this from the other known forms. It bears a close resemblance in outline to Streblopteria media.

Aviculopecten (Lyriopecten?) cancellatus, sp. n.

(Plate XII, Fig. 7.)

Shell small, suborbicular; length and height equal; lower and

lateral margins uniformly rounded. Right (?) valve moderately convex, hinge four-fifths the greatest length; beak nearly central; anterior wing small, ill-defined; posterior wing larger, separated from the body by an oblique plane surface, rather flat; no indications of a byssal sinus. Surface finely cancellated by uniform, high, regular radiating and concentric ridges, the latter sub-imbricating. There is little to determine which valve our single specimen represents, it may quite possibly prove to be a left valve. There is some resemblance to small specimens of L. orbiculatus. The most that can be said is that our shell possesses a decidedly Devonian aspect. Nodule layer at Moot's run.

Linatulina (?) ohioensis, sp. n.

(Plate II, Fig. 20; Plate III, Fig. 10.)

Shell of moderate size, obliquely and rather narrowly oval; height over one-fifth greater than length; hinge line very short; surface with distant, irregular furrows. Left valve moderately convex near the beak, elsewhere quite flat, with hinge line equal to about one-half the greatest length; valve not very oblique, umbonal ridges meeting at the beak at less than a right angle, beak somewhat acute; anterior ear well-defined, but small, rounded and separated from the body of the valve by an abrupt descent, its margin concavely sinuated below; posterior ear very small and obtuse. The posterior margin makes a broad curve which is straightened above, but curves more rapidly in passing into the very convex front outline. The valve is marked by about 20 distant and very irregular narrow and deep radiating striæ and folds. Right valve very oblique and short, hinge line relatively longer, posterior margin straight, making an angle with the hinge of about 130°; posterior angle produced; anterior ear small, convex, projecting, separated from the valve by a profound acute byssal sinus; marked by about four or five distinct costæ; markings of the body as in the left valve. Evidently the shell was quite inequivalve.

Height of perfect left valve 20 (23) mm; lenght 15 (18) mm; hinge 9 (8) mm; height of right valve 12 mm; lenght 10 mm (?), hinge 8 mm.

A number of specimens have been secured only one of which, unfortunately, was a right valve. The shell is so thin as to make it

peculiarly liable to distortion. The species is normally somewhat longer than that drawn on Plate III. Though the hinge was not seen, this species seems allied to Limatulina than any other genus of the family. Confined to the strata above congl. II, chiefly near the very top of the Waverly as exposed in the county.

Streblopteria media, sp. n.

(Plate III, Figs. 8–9.)

(Cf. *L. similis*, Walcott.)

Closely allied to *S. similis*, Walcott, of medium size, rather broadly ovate, not oblique, moderately convex near the beaks.

Left valve most convex, anterior ear broadly rounded, depressed, separated from the body of the body of shell by an abrupt inclination, sinus moderately concave, remainder of the margin a rather regular convex curve approaching a straight line near the point of union with the hinge, which is short, and not forming a well-defined posterior ear; beak acute, somewhat projecting; greatest convexity a short distance from the beak; surface marked by rather distant and coarse, but inconspicuous radiating striæ, or apparently smooth. The right valves differ little in form, but the byssal sinus is very sharp and deep and the anterior ear is long and rather prominent and separated from the body of the shell by a deep groove. The posterior ear is obsolete. The surface is nearly smooth, except the anterior ear which is very strongly marked by radiating striæ.

From *S. similis* this species differs in being relatively broader, especially in the left valves, and lacking the fine striations seen in small specimens of that species. It resembles very closely indeed, *Crenipecten foerstii* of the coal-measures, but differs from it in the proportions of the ears and does not seem to possess the crenulated hinge. The only other American species with which comparison is necessary is *S. tenuilineatus*, from the coal-measures of the West.

Height of a right valve 16 mm; greatest length 16.8 mm; length of anterior ear 7 mm; distance from hinge line produced to anterior angle of shell below byssal sinus 5 mm. Height of a left valve 19 mm; length 19 mm; length of anterior ear 6 mm; greatest length at about 10 mm. from beak. Numerous closely agreeing specimens from

the layer a few feet below congl. I. The species is also found forty feet below congl. I, at Union Station, in large, finely preserved specimens, a left valve measuring in length, 25 mm, in width 23.5 mm.

Streblopteria squama, sp. n.

(Plate VII, Fig. 14.)

Smaller or medium size, with extended hinge-line and ovate outline. Left valve quadrately ovate; length and height about equal; hinge about three-fourths the length; anterior outline nearly straight, slightly convex below and concave at the ear; posterior outline gently and uniformly convex; anterior wing largest, nearly rectangular, not very distinctly separated from the body; moderate posterior ear obtusely angular, passing without interruption into the general surface of the body; surface slightly convex, ornamented only by fine, crowded imbricating lines, epidermis very thin. Shales below congl. I.

This species is considerably smaller than the average specimens of S media and is more broadly ovate, with a longer hinge-line. No traces of radiating striæ could be seen.

Streblopteria gracilis, sp. n.

(Plate VII, Fig. 12.)

Shell of medium size, elongate, with very short hinge.

Left valve narrowly elliptical, length four-fifths the height, hinge less than half the length; posterior margin a uniform slight curve to the almost obsolete ear: anterior margin very abruptly flexed at the umbonal slope to the short, obtusely triangular ear; surface convex, ornamented by concentric and obscure radiating lines. Free-stone of middle Waverly (?) This species resembles the larger form of S. media, but is at once distinguished by its narrower form and short hinge-line.

Pernopecten shumardianus, Wm.??

(Plate XII, Figs. 13–5.)

A considerable number of nearly perfect valves are represented

in our collections from the nodule layer at Moot's run. Our largest specimen agrees in all preserved characters with the species quoted doubtfully as P. shumardianus The opposite valve is more nearly flat and was poorly preserved. The great vertical range of this group as well as the perplexing relations of the genera Pernopecten and Entolium make it difficult to base conclusions upon their distribution. Compare Bulletin Denison University, Vol. II, p. 23.

Pterinopecten cariniferus, sp. n.

(Plate XII, Figs. 8–9, 42.)

Shell small, sub-rhomboidal, slightly oblique; greatest length (of body) below or at about the middle of the valve; length from one and one-fourth to one and one-fifth the height; lower margin nearly even elliptical curve, becoming rather rapidly flexed behind till its direction makes a little more than a right angle with the hinge, which it meets by a gentle outward curve; anterior margin abruptly curved above the middle, forming an angle of about 45° with the hinge, to the deep byssal sinus. Right valve slightly convex; hinge-line straight longer than the body, acute at both extremities; beaks low, situated at about the anterior one-third; posterior ear or wing large, triangular, depressed, but not distinctly outlined from the valve, anterior ear acute, produced. Left valve more convex; beak slightly projecting; surface marked by regular distant radiating ribs and distant concentric folds, producing a pretty cancellation. The radiating markings of the right valve are less conspicuous.

This species has a distinct Devonian habit. Nodules in shale at Moot's run, 4½ miles west of Granville.

The right valve is very like some states of Pterinopecten vertumnis. The resemblance is close to Pt. exfoliatus, but the ear is too small in that species.

Pteronites (Leptodesma) ? obliquus, sp. n.

(Plate VII, Fig. 7; Plate IV, Figs. 20.)

A very oblique species occuring in the free-stone of the middle Waverly may be recognized by its great obliquity and convexity. The

anterior projection is apparently acute, the lower margin forming an angle of 30°–40° with the hinge. The posterior wing is imperfect, but was probably slightly produced. Fig. 20 of Plate IV, is certainly wrongly restored, being, without doubt, the same species as the one first referred to. The relation to certain Chemung species, especially Pt. inoptatus, is very close.

Leptodesma (?) scutella, sp. n.

(Plate IV, Fig. 16.)

A number of specimens of a little shell at first referred to Pteronites indicate a species belonging to section umbonata, but apparently distinct from any Chemung species. Sub-rhomboidal or nearly semiovate, anterior wing short, acute; body inclined about 50° to the hinge line, which it about equals; posterior margin concave, upper angle produced, beak sub-anterior; surface gently convex, except the posterior wing, marked by equidistant lines of growth. With the above.

Posidonomya (Streblopteria) fragilis. sp n.

(Plate VI, Fig. 1.)

The specimens on which this species is founded differ from all Waverly species and all others known to me. The species may be compared with P. laterugata, but is less alate and has much more prominent beaks.

The wings are almost too prominent for a member of the genus quoted and the presence of indistinct radiating striæ passing over the coarse plications adds to the incongruity.

The right valve is broadly oval or nearly circular, with the posterior ear considerably produced, anterior one less distinct and shorter, margin below the ears a reniform broad curve resembling a circle; surface of the valve rather flat, but somewhat suddenly elevated near the beak, which is acute and slightly projecting beyond the hinge; hinge line straight, rather short; surface marked by distant irregular folds and indistinct, fine, minute radiating striæ. Height 29 mm;

greatest length 31 mm. Found at Moot's run, four miles west of Granville, in nodules at the very bottom.

Promacra (?) *truncatus*, sp. n.

(Plate III, Fig. 30.)

Without absolute certainty that this species can be properly referred to Promacra, it remains certain that a very peculiar species exists with a general resemblance externally to the assemblage so designated. Our specimen is incomplete and doubtless distorted, though the peculiarities thought to be due to pressure may be inherent. Shell elongate, produced anteriorly; beaks in front of or near the middle; strongly convex (in our specimen the transverse section is broadly cordate.) Dorsal margin in front of the beak straight; hinge extending a short distance behind the beak; posterior margin very oblique, meeting the nearly straight ventral margin at a very acute angle, at or near the lowest part of the shell; (anterior extremity not seen); post umbonal ridge very strong, acute; plane of the post umbonal slope at right angles to the sides of the shell, plane or somewhat concave, giving the shell a curious truncate appearance; surface marked by strong irregular furrows and striæ, which in passing over the post umbonal ridge make a very acute angle; beaks incurved to the plane of hinge; shell gaping widely behind, apparently closed or nearly so anteriorly. Allowing for all probable distortion the shell seems distinct from all others. It could not have been so extended anteriorly as *P. andrewsi*, nor as strongly marked as *P. nasutus*, though some indications of the radiating striæ of that species, which ours most resembles, can be seen.

The three known species are all from the same relative horizon. *P. missouriensis*, from the sub-carboniferous rocks of Missouri, *P. nasutus*, from Choteau limestone of the same state, and also in Belgium, while P. andrewsi was found by Meek, in the Waverly group of Ohio.

Leiopteria ortoni, sp. n.

(Plate VII, Fig. 1.)

Shell of medium size, triangularly ovate to subrhomboidal; body

obliquely ovate, length considerably exceeding the height; post basal side considerably extended; ear straight, almost acute, anterior side obliquely truncate; body making an angle of about 45°, with the hinge line. Left valve shortest, most gibbous; beak one fourth from anterior, rather prominent, but not incurved, ear rather convex, with a broad shallow byssal sinus, wing large flat, the posterior margin meeting the hinge at an angle of about 90° or more, acute at the very angle only. The hinge margin is greatly thichened. The difference between the two valves is slight, the beak of the right being generally in advance of the other, and the front margin is more uniformly curved.

Entire length of hinge linge 22 mm, height 14 mm, length from beak to antero-ventral angle 19 mm. Surface marked by concentric lines. This species somewhat resembles L. rafinesquii, H., but differs in being more oblique and longer, with straighter and longer hinge and less produced beak and straighter posterior margin. Leptodesma hector is somewhat more like our species, but exhibits an opposite extreme. This species is characteristic of a zone several feet thick, about 40 feet below conglomerate I, in connection with other fossils of a more or less Devonian habit. This species may be compared with L. torreyi, but is not so produced; it also resembles Leptodesma nereus. Compare also L. naviforme.

Leiopteria halli, sp. n.

(Plates VII, Fig. 31, Cf. Fig. 32.)

Shell of moderate size; sub-rhomboidal; body narrowed above, obliquely ovate; height greater than length at hinge; margin strongly sinuous; ears rounded, somewhat depressed, short; wings broad, extended, acute; hinge-line straight. Valves nearly similar, left valve rather more convex. Right valve moderately convex; body diverging from hinge-line at an angle of about 45°; wing acute; posterior margin strongly concave, postero-ventral extremity rather sharply curved; anterior margin abruptly flexed near the middle, anterior to which it is gently concave; ear rounded, depressed. Left valve with smaller wing more convex, especially ventrally. Surface of both valves marked by conspicuous concentric folds. Hinge with a decided groove and thickened ridge. Beak of right valve high, but not projecting dorsally, that of the left valve extending beyond hinge-line.

Length of right valve from beak to postero-ventral convexity 17 mm; hinge posterior to beak 13 mm, height 13 mm; greatest diameter (from ear to postero-ventral angle) 19 mm. This species is intermediate in characters between *L. ortoni* and *L. rafinesquii*. Like the latter the wing is acute and the posterior margin excavated, like the former the body is very oblique. Top of freestone, Granville.

L. halli may be compared with Leptodesma clitus, H., but is not so produced behind and rather less oblique, it is also less oblique than L. lepidum. Perhaps the closest resemblance is with Leptodesma lysander, but the wing is not so extended.

Leiopteria, sp.

A very small species of this genus was secured from the lower shaly layers at Moot's run, probably below the horizon of L. ortoni, but which more nearly resembles L. halli in the acute wing and excavated posterior margin. The species is known only from a single right valve with a short, lobate, obtuse ear. The body is more oblique and narrower than in either of the preceeding species.

Prof. Hall states that only two of the fifty-seven species of Leptodesma occur below the horizon of the Chemung, Leiopteria, on the other hand, reaching its greatest development in the Hamilton. Pterinopecten has many species below the Chemung, while Crenipecten and Pteronites are unknown below. Glyptodesma is not known above the Hamilton.

Leiopteria sp?

(Plate III, Fig. 6)

A fine large species is indicated by a fragment not exhibiting the structure of the hinge and ears. The body is very flat, but the anterior ear is well-defined by a strong ridge, the umbonal slopes make an angle with each other of about 60°. The posterior lower angle is produced. Surface marked by obscure folds and striæ. Length along post-umbonal ridge 27 mm, along anterior umbonal ridge 17 mm. The considerable obliquity and flatness of the body are the obvious characters which are noted especially because the shell is found in a higher horizon than those previously mentioned.

Myalina michiganensis, Win?

(Cf. *M. swallovi.*)

(Plate IV, Fig. 6.)

The only difference between this species and M. swallovi of the coal-measures is in the greater size of the protuberance under the beak, but Meek says specifically: "This species (M. swallovi) varies somewhat in the size of the protuberance under the beaks; in some individuals it is well developed, and gives the shell much the form of *Modiola*; while in others it is smaller, so as to present more the appearance of a *Mytilus*." Perhaps it may be sufficient to indicate the probable genetic relations of these forms.

Modiola waverliensis, sp. n.

(Plate I, Fig. 9; Plate IV, Fig. 10; Plate VII, Fig. 29?)

(There has been no opportunity to consult the description of M. metella, H. so the possibility of agreement with this Chemung form is not excluded.)

Nearly like M. nevadensis, Wal., but less elongate. Transversely elongate, narrowly and uniformly rounded anteriorly, lower outline very gently curved, posterior end rather more broadly rounded than the anterior, the outline above diverging rather strongly to a point between the middle and the posterior third, where it meets the nearly straight hinge. Beak posterior, somewhat overhanging. Post umbonal slope quite well marked near the convex umbonal region, posterior part of shell rather flat. Length somewhat greater than twice the width.

A number of casts have been found in the freestone of the middle Waverly. Those specimens preserving the shell markings differ slightly from the cast first referred to and have fine concentric striæ. These may indicate a distinct species, but probably the apparent differences correspond to the different states of preservation.

Schizodus newarkensis, sp. n.

(Plate X, Fig. 1)

Shell large, obliquely ovate, produced. Beak prominent, not projecting much beyond the hinge. Surface quite convex in the umbonal region, becoming flattened posteriorly. Lower margin a gentle curve, very oblique to the axis, anterior margin strongly convex, posterior margin a gentle curve meeting the lower line acutely. The post-umbonal region expanded, flat; anterior umbonal slope rather abrupt. Beaks anterior; surface marked by fine regular striæ. Our single specimen is very remarkable for the strong curvature of the surface below, opposite the beaks and flatness of the posterior ear. This may be due to oblique pressure as the opposite valve is crushed and displaced. Notwithstanding this the ovate form, large size and position serve to distinguish it. Length 62 mm; height 50 mm; convexity of both valves about 23 mm. Collection of W. F. Cooper. Highest layers 1 mile north of Newark.

Schizodus chemungensis, var? aequalis, H.

(Plate I, Fig. 25.)

Shell of rather large size, moderately convex; beaks projecting, rather high; length slightly greather than the height; form subquadrate, produced at the lower posterior angle; lower margin nearly uniformly convex, with a slight sinus in front of the posterior angle; posterior margin nearly straight and nearly parallel to the longitudinal axis of the shell; anterior margin strongly curved; anterior umbonal ridge rather inconspicuous. post-umbonal ridge prominent, in front of it a rather deep groove extending from the sinus of the margin toward the beak; post-umbonal slope rather steep, concave. Surface marked by numerous fine concentric striæ and coarser ridges. The right valve is most convex in our specimens. Height 42 mm; length 48 mm; (height 38 mm; length 42 mm.)

Freestone of middle Waverly at Granville, and 6 miles northwest. Collected by W. F. Cooper and C. L. Herrick.

We are convinced that the attempt to specifically discriminate the

Waverly from the Chemung form is futile. Hall states that the present species differs from S. chemungensis, var. quadrangularis in that the base is more broadly rounded and the anterior portion is more expanded below, giving the shell a more equilateral appearance. This is not appreciably so in our specimens, though considerable variation is seen. The close relation between the Chemung and Waverly is here obvious.

Plate IX, Fig. 20 represents a form still more like the Chemung species.

Schizodus cuneus, H.

(Plate V, Fig. 15.)

This little species is not rare in the freestone of middle Waverly, and may be easily recognized by its triangular form and small size.

Schizodus medinensis, Meek.

(Plate I, Fig. 16.)

The figured specimen is imperfect, but characteristic specimens are common in the freestone with the above.

Orthonota rectidorsalis, Win.

(Plate X, Fig. 1)

Shell of medium size, elongate, moderately convex. Hinge and ventral margins nearly straight and nearly parallel; beak sub-terminal; anterior margin gradually curved to above one-half the height, then abruptly curved and slightly concave to the beak, which is very slightly elevated. Posterior margin angulate curved, making an angle of about 110° with the hinge line and passing by a more gentle flexture into the ventral border. The greatest thickness is about one-third from the anterior, the surface is evenly convex along a line passing toward the postero ventral angle. There is a rather deep groove passing parallel to the hinge from the beaks.

Genus Prothyris, Meek.

Prothyris meeki, Winchell.

This species occurs frequently in the shale below congl. II, but is by no means limited to that horizon. Its range and legitimate limits of variation have not been fully studied.

Sanguinolites (Goniophora) senilis, sp. n.

(Plate IX, Fig. 28.)

Cf. *Sanguinolites cuneatus*, DeKoninck, and *Goniophora subrecta*, Hall.

Shell of rather large size, nearly rectangular, hinge and ventral margins nearly parallel, nearly straight and of nearly equal length. The anterior dorsal margin is nearly straight, making with the hinge an angle of about 120° or less, somewhat produced; posterior margin truncate at about a right angle and again obliquely truncate at the upper third (sometimes apparently curved rather than doubly truncate; in most specimens the postero-inferior angle is more acute and produced than in the one figured, thus approaching G. subrecta, H.) Surface quite convex along the very prominent and rather acute post-umbonal ridge, the greatest convexity being half way from the beak to the postero-ventral angle. On either side of the ridge the surface is plane for some distance, but anteriorly becomes concave, forming a broad sulcus passing from the middle of the ventral margin toward the beak; posteriorly the surface is flat for a considerable distance from the upper angle. The umbo is rather prominent. The surface is ornamented with very prominent, rather irregular, close, concentric lines, which are acutely angled upon the umbonal ridge. Length 60 mm; height 25 mm; beak distant from the anterior about 11 mm. Found only in shales four feet below conglomerate I, near Granville, O. In some specimens the resemblance to S. cuneatus, Dekon., approaches identity. From Goniophora subrecta it differs chiefly in the less elevated anterior extremity and slightly less produced infero-posterior angle. The relation is so obvious that we regard this shell as increasing the Devonian character of our division I.

Sanguinolites marshallensis, Win. ?

(Plate V, Fig. 11; Plate VII, Fig. 10.)

This shell bears some resemblance to S. transversus, Dk. (= Cypricardia rigida), but differs in the posterior margin. Shell sub-quadrate or sub-ellipsoidal, transversely elongate, with greatest convexity above the middle; hinge nearly straight and somewhat shorter than the shell, at its posterior termination being the greatest height of the shell; ventral margin shorter, somewhat concave or nearly straight, rapidly curving anteriorly to a point above the middle of the height, where it intersects the short, concave antero-dorsal margin; posterior margin doubly truncate, first below for two-thirds the height by a line inclined with the ventral about 130°, above by a shorter line making nearly the same angle with the cardinal line, giving the shell a nasute appearance behind. A prominent ridge passes from this projection toward the beaks and a similar one from the lower posterior angle, between which a decided sulcus is frequently observed, especially in large specimens. A less distinct sulcus extends from the middle of the lower margin towards the somewhat flattened, incurved beaks.

The following measurements illustrate the proportions: Length 22 mm, height 11 mm, convexity of single valve 3-4 mm; L. 33 mm, H. 15 mm; L. 28 mm, H. 14; L. 24 mm, H. 12.5 mm; L. 40 mm; H. 18 mm.

The identification as above was made at the suggestion of Prof. Winchell, as we were unable to harmonize the description with our specimens. This may be accounted for by the fact that the description was drawn from rather young forms, while ours have the peculiarities strongly marked.

Free-stone of middle Waverly, Granville, O.

Sanguinolites unioniformis, Win.

(Plate IX, Figs. 5, 7–9.)

Quite a number of very small shells, with rather constant characters from the basis of this description. The interior has in no case

been seen, but there is at least a close resemblance to Winchell's species as gathered from the description.

Shell small, compressed, elongate elliptical, with nearly parallel margins and sub-terminal beaks. Rather more than twice as long as high, height nearly the same anteriorly as posteriorly. Hinge-line two-thirds the entire length, often diverging posteriorly, sometimes shorter; postero-dorsal margin very obliquely truncate, curving more rapidly near the middle of the height and passing by a rapid curve into the nearly straight ventral margin. Anterior margin rather distinctly concave above the middle, strongly convex bejow. Beaks minute, not projecting, near the front; posterior-umbonal slope gentle, no well-defined ridge; shell thin, surface marked by fine lines of growth. Length 13 mm, height 5.2 mm; hinge-line 8 mm; beak 2 mm. from anterior. Shale 4 feet below Congl. I, at the "Dug-way," Granville, Ohio. No. 1372.

Sanguinolites (*Sphenotus*) *transversus*, Dekoninck.

Sanguinolites (Cypricardia?) rigida. W. and W.

(Plate IX, Fig. 22.)

"Shell elongate, quadrangular, a little widest at the posterior end. Dorsal line straight, bounded by a rather broad escutcheon, which is more than half as long as the entire length of the shell. Anterior end truncate, prolonged near the basal margin; posterior extremity obliquely truncate; basal line straight, slightly emarginate, a little anterior to the middle, by a shallow sinus which crosses the shell from beak to base. Lunule large, deeply marked; beaks small, flattened on the umbones, and enrolled, situated anteriorly; umbonal ridge very prominent and angular, extending from the beak to the posterior-basal angle. A second, but less prominent ridge passes about midway between the first and dorsal line. Surface marked by sharp, closely-arranged lines, parallel to the margin, which are bent at right angles as they cross the umbonal ridge, and less abruptly at the minor ridge. Interior of shell with a sharp muscular ridge passing from the anterior side of the beaks, with a forward curvature, about ⅔ distance across the shell. Hinge-teeth absent, probably partially external ligament,"

This species is found rarely in the shales below the congl. I.

There is an *a priori* improbability that this species exists in Belgium as well as in America, but the identification of Dekoninck is positive.

Sanguinolites (Sphenotus) contractus, W. W.

(Plate XII, Fig. 4.)

A form identified with this Chemung species is found in shales at Moot's run, in the nodule layer, hence perhaps sixty feet below the horizon of S. rigidus=transversus. From that species it differs in being less robust, longer, less rigid, and in having less obtuse post inferior extremity.

The group of species here associated is a very intimate one and the specific distinctions may prove illusory.

Sanguinolites (Sphenotus) flavius, H.?

(Plate IX, Fig. 10.)

The resemblance between Sp. valvulus and Sp. flavius, as figured by Hall, is so close that one would be tempted to combine them unless full suites attest their autonomy.

Our specimens vary considerably, and in the surface characters resemble Sp. flavius, but often have more the outline of Sp. valvulus. The resemblance to small forms of *Sanguinolites naiadiformis* is great. From S. unioniformis with which they are associated they may be distinguished by the greater size and more produced posterior margin. Length 48 mm; width 18 mm.

Specimens found only in layer of shale a few feet below conglomerate I.

Sanguinolites (Glossites) amygdalinus, Win.?

This species is apparently represented in our collections, but not in specimens in suitable condition to describe. Its position is in the shale below congl. I.

Sanguinolites michiganensis, Win.

(Plate VIII, Fig. 10.)

This species has been a puzzle to me, but Prof. Winchell suggests that it is his S. michiganensis. The place and date of publication of this species are unknown to me. The resemblance is rather with Pleurophorus or Goniophora apparently. Found in the shale below conglomerate II, at Newark.

Sanguinolites aeolus, Meek.

(Plate VIII, Figs. 1, 11.)

This species is evidently causing some confusion. Walcott figures specimens under this name from the Eureka district, which are at least very doubtful. Our own specimens do not present entire agreement, but are not well preserved; they are derived from the shales below congl. II, with Allorisma winchelli. Meek asserts that the stratum referred to is upon the same horizon with that of the Cuyahoga shale. In as much as there is some reason to doubt this or to suspect that the Cuyahoga contains several horizons higher than this one, all identifications should be made conservatively. We suspect the identity of the specimens figured with the Cuyahoga species and reserve judgement.

Sanguinolites obliquus, Meek.

(Pal. O., Vol. II, Page 306.)

This shell is abundant one mile south of Newark, in the shale below congl. II, with Allorisma winchelli.

The following measurements indicate the typical proportions :

No.	Length.	Height.	Thicknes.	Height ⅓ from front.	Thickness ⅓ from front.	Proportions.
1	47	16	14	16	11	1–.34–.29
2	46	17	13	17	11	1–.36–.28
3	43	15	11	———	10	1–.34–.28
4	———	17	13	———	———	
5	———	21	17	———	———	
6	(35)	13	10	13	7	
7	(50)	17.5	16	———	———	
8	42	17	13	16	11	1–.38–.30

Sanguinolites naiadiformis, Win.

(Plate IV, Fig. 2.)

"Length 2½ the height; laterally flattened below the umbo; dorsal and ventral margins parallel or nearly so, the ventral sometimes with a broad, shallow sinus extending upward over the valves and vanishing near the umbo; a distinct umbonal ridge flattening out near the postero-ventral angle, at which place the outline presents a rounded angulation; postero-dorsal slope making with the dorsum an angle of 45°. Length 2¾ in; height 14-16; thickness ½ in."

The specimen figured is less typical than others from the freestone in that it lacks the ventral sinus. Length 75 mm; height 28 mm; convexity 16 mm.

A variety rather more common than the typical one has the umbonal ridge more prominent and the anterior ventral curve more convex. Several specimens measure about as follows: Length 75, 63, 66; height 28, 24, 26; convexity 20, 17, 18; length of lunule 15, 13, 13. This form extends into congl. II.

A small specimen from the shale below congl. I, closely resembles the above, but is smaller, measuring 36; height 17; convexity 9 (9); lunule 8. Plate IX, Fig. 3.

Allorisma (*Sanguinolites*) *nobilis,* Dekoninck.

(Plate X, Fig. 5.)

Very large, elongated, expanded and somewhat angulated posteriorly, nearly three times as long as high at the hinge, rather flat, greatest convexity near the middle of the valves.

Hinge line nearly straight and almost parallel with the very slightly curved lower margin; beak between 1-4 and 1-5 the distance from anterior margin, which is nearly straight and extends a little more than half the height of the shell, forming a rather acute angle; posterior margin nearly evenly curved or doubly sub-truncate. Surface marked by very strong, irregular, concentric ridges. The post-umbonal ridge is near the hinge and is very slightly elevated, below it are two still fainter ridges passing from the beak to the lower posterior angle and a

point half way to the point where the umbonal ridge terminates. The single specimen seen is a little imperfect so the curvature of the beak could not be certainly seen. This shell is as large as *A. subcuneata*, which it greatly resembles in surface characters, but the presence of the Pleurophorus-like ridges and slightly angled posterior margin, and less convexity serve to readily distinguish it.

Near the top of free-stone at Granville, collected by W. F. Cooper.

This shell is apparently identical with S. nobilis, the only differences noted being the slightly greater anterior projection in our specimens, which are thus rather longer.

Allorisma cooperii, sp. n.

(Plate VI, Figs. 10)

Shell of medium to large size, rather flat, expanded, and short. Very little more than twice as long as high; middle region evenly convex; beak not prominent, gently incurved, situated near the juncture of middle and anterior thirds. Hinge and lower margins nearly parallel, latter gently curved. Anterior margin rather long, slightly concave, meeting the lower margin below the middle at an acute produced angle. Posterior margin parabolic, nearly equally curved above and below. The height is nearly the same at the anterior and posterior thirds. The surface is marked with the usual concentric striæ, but whether granulated or not the condition of our specimens forbids conjecture. The post-umbonal ridge is close to the hinge line and not very prominent, while the antero-dorsal margin has no lunule.

Length 69 mm; height at beak 33 mm; distance of beak from anterior 20 mm.

This is a much shorter species than A. subcuneata, M., of the coal-measures, and has a longer anterior portion.

Two specimens from the upper layers of the free stone have been found with concurrent characters. Collected by W. F. Cooper, at Union Station, and by C. L. H., north of the "Dug-way"

Allorisma winchelli, Meek.

(Plate VIII, Figs. 2–4.)

Occurs in great abundance in a layer immediately below the 18-

inch conglomerate above the quarry rock in the south Newark quarry. It is here associated with *A. ventricosa*, *Edmondia* sp. *Sanguinolites obliquus*, and *Prothyrus meeki*.

The following measurements illustrate the range of variation at this place:

	Length.	Height.	Thickness.	Height at ⅓ from post. end	Thickness at ⅓ from posterior.	Angle of antero-ventral margin.	Angle of antero-dorsal.	Anterior wing	Length to height to thickness.
1	51	23	22	23	18	42°	120°	5	1–.45–.43
2	48	23	21	23	17	40°	113°	4	1–.47–.43
3	47	24	22	25	20	40°	112°	3	1–.51–.46
4	53	23	20	22	14	38°	121°	4	1–.43–.37
5	(52)	23	20	22	16	37°	113°	4	
6	——	24	22	22	18				
7	(26)	12	10	7	7				
8	——	14	11	13	7.5				
9	47	23	22	24	17				
10	35	17	17	19	15				

Allorisma winchelli has once been found in shales above congl. I, showing that it was continuous throughout the period during which the free-stone was deposited. The animal lived buried in the mud, and is found with the valves in connection oblique to the lamination, and only in rocks which were originally mud of the shallow bays.

Allorisma ventricosa, Meek.

(Plates VIII, Fig. 6; Cf. Plate VII, Fig. 33.)

Our specimens differ considerably from Meek's description and also among themselves. The one figured expresses the extreme development of the tendency of the species, being shorter and more abruptly curved antero-ventrally and with more prominent beaks than others. A well marked ridge marking off the antero-umbonal slope is especially characteristic.

Length 34 (24); height 29 (19); thickness 18 (13); height at ⅓ from posterior 22 (15); thichness at same point 13 (10); anterior wing 5; angle of postero-ventral margin with hinge line about 56°. Measurements in parenthesis are of another specimen.

Allorisma convexa, sp. n.

(Plate XII, Fig. 27.)

Shell of medium size, quite tumid, with parallel margins and numerous fine striæ. Length nearly 2½ times the height; hinge and lower margins parallel and of equal length; lower margin abruptly rounded to the middle of the height, passing sharply into the concave antero-dorsal line; lunette well defined; posterior margin broadly rounded with slight angulation at the termini of two faint ridges between the post-umbonal ridge and the hinge; surface highest near the middle, flattened postero-dorsally; post umbonal ridge faint, the supra-umbonal ridges inconspicuous, but producing slight deviation in the numerous and regular concentric striæ. The cast shows a long cardinal groove. This shell is some respects a miniature of A. nobilis, but is much more convex. The radiating striæ characteristic of Allorisma may be detected upon the cast. From A. winchelli, which it exactly resembles in size, it may be distinguished by the parallel sides and the form of the posterior margin. From all other forms of this age it will readily be distinguished. Length 57 mm; height 23 mm; beak from the front 10 mm; convexity of both valves about 15 mm. Free-stone layers of middle Waverly, 6 miles northwest of Granville. Collected by W. F. Cooper.

Macrodon?? triangularis, sp. n.

(Plate VIII, Fig. 8.)

A single right valve differs so from all associated forms that very little idea is afforded of its relations.

Shell thick, nuculiform, large; outline subtriangular, beaks rather prominent, somewhat incurved; hinge apparently flexed at nearly a right angle at the beak, anterior margin nearly straight, meeting the gently curved lower margin by an abrupt curve; posterior margin very short, forming an acute angle with the lower margin and a very obtuse one with the curved hinge line; post umbonal slope narrow, inclined to the general surface of the valve at nearly a right angle; surface marked by concentric striæ and folds; greatest convexity

above the middle. Length 41 mm; height 35 mm. Free-stone of upper Waverly. The hinge characters are unknown.

Microdon reservatus, Hall.

(Plate IV, Fig. 14.)

This species is common in the free-stone of middle Waverly, but neither of our figures gives a typical form. Fig. 14 is abnormally elevated behind. Fig 4 of Plate X, is a small variety with beaks more central than usual. See Modiomorpha, below.

A typical specimen is sub-quadrangular, 1½ as long as high, flat, and finely marked concentrically. The lower margin is a very shallow elliptical curve; postero-dorsal slope slightly inclined, nearly plane; hinge line behind the beak nearly straight; posterior margin making with it an angle of about 120°, very slightly curved, anterior margin slightly concave forming an angle of nearly 140° with the hinge, antero-inferior projection rather abruptly rounded. Hinge in our casts showing only a shallow groove before and behind the beak. The generic reference is unsatisfactory.

Grammysia rhomboides, Meek.

(Plate VIII, Fig. 12 ?)

Typical specimens are frequent in the free-stone of middle Waverly. (Our figure is from an unusual form which may not represent this species.)

The relations of the associated form figured on Plate IV, Fig. 1, are unknown.

Gammysia hannibalensis, Shum.

This species is not very common in the free-stone of middle Waverly. Certain forms of Palæoneilo elliptica are are frequently mistaken for it. Fig. 13, of Plate IV, is apparently a fragment of this species.

Grammysia ventricosa, Meek.

Fine typical specimens are found in the Allorisma layer below conglomerate II, especially at Rushville. See Pal. O. Vol. II; also doubtfully identified from the free-stone below this horizon, at Newark and Granville.

Grammysia sp.

(Plate XII, Fig. 3,)

This small species has somewhat the aspect of an Edmondia and has not been carefully studied. From the nodules at Moot's run.

Modiomorpha hyalea. H. ?

(Plate X, Fig. 4.)

This identification is provisional. Our specimens are shorter and have more the aspect of a Grammysia. The species was derived from Granville, however, and the form here figured approaches it as nearly as any seen. Freestone of middle Waverly.

Edmondia depressa. H.

(Plate VIII, Fig. 5.)

Shell thin, subquadrate, only moderately convex, umbones prominent, beaks incurved, approximate, near the front margin. Hinge line straight, equal to over one-third the entire length; post umbonal ridge rather prominent, extending to postero-ventral angle; post-umbonal slope bisected by an indistinct ridge extending from the umbo; pre-umbonal slope narrow; posterior outline nearly straight, meeting the hinge line at an angle of about 111°, passing into the lower outline by an abrupt curve; lower line nearly parallel to the hinge, curving very rapidly to its junction with the rather straight front margin, which makes nearly a right angle with the hinge. Surface covered with fine concentric striæ and coarser folds parallel to the margin.

Our specimen gapes posteriorly and below, but probably the edges naturally apply all around. Greatest convexity upon the post umbonal ridge about one-fourth the distance from the beak to posterior angle. A shallow sinus extends from the umbo to the middle of the lower margin. Length 31 mm, height 22 mm, thickness 14 mm, beak about 7 mm, from anterior margin, hinge 23 mm. Allorisma layer, below congl. II, at Newark and Rushville. Not having access to Prof. Hall's description, I am unable to make direct comparisons, but have no doubt that this is the species in question. The comparison with E. tapesiformis, Meek, reveals many differences, that species also seems to come from a different horizon.

Edmondia burlingtonensis, W. and W.

(Plate IX, Fig. 27, Fig. 17 (?); Plate IV, Fig. 18.)

Our species is doubtless the one generally identified with E. burlingtonensis and Prof. Winchell has made direct comparison of our forms with Iowa types and sustains the identification. There is, however, a wide range of variation in specimens on the same slab, the majority being almost like E. radiata, H., in form. The original description runs as follows:

"Shell of medium size, broadly subelliptical in outline, with regularly ventricose valves, breadth equal to three-fifths of the length. Beaks situated within the anterior third, strong, prominent, and incurved. Hinge-line and basal margin gently and equally curved; anterior and posterior extremities broadly and equally rounded. Surface marked by numerous strong, concentric undulations, parallel to the margin of the shell. In full-grown individuals there is a shallow, undefined sulcus, commencing near the centre of the shell, and reaching the border near the middle of the base." "Differs [from E. radiata] in having the posterior extremity narrower than the anterior, instead of much broader; and also in the concentric undulations."

After an examination of perhaps fifty specimens, all from the same bed within a few inches of each other (vertically), we observe the following nearly constant differences. The posterior part of the shell is higher than the anterior; sulcus well-defined; posterior margin much more broadly rounded than the anterior and obliquely sub-

truncate above; finally, we are not sure the hinge structure is that of Edmondia.

To all appearance our specimens agree with the smaller form figured in Vol. V, Pal. N. Y.,.Part I, under the name Macrodon ovatus, though its relation to the typical larger form is less obvious. In some of our specimens the teeth of Macrodon were doubtfully observed.

Ctenodonta (Nucula) iowensis, W. and W.

(Plate I, Figs. 14, 17.)

A nuculoid shell resembling the one quoted is very common in the layer below congl. I.

Shell small, triangularly subovate, quite ventricose. Beaks about one-fourth or less from the anterior, prominent, acute, and incurved. Hinge abruptly bent at a little less than a right angle with about 10 posterior and 4–5 anterior teeth, anterior margin obliquely truncate; lower margin a nearly regular semi-elliptical curve. Surface marked by numerous plicæ, especially near the margin, where the epidermis is thickened. Length 10.5 mm, height 8 mm, thickness 6 mm. (?)

Ctenodonta (Nucula) stella, Win.

(Plate IX, Fig. 14.)

"Shell very small, elliptic-ovate, with sub-central beaks. Anterior cardinal slope arched, posterior nearly straight; extremities rather sharply rounded; ventral side semi-elliptic. Anterior hinge-plate with 17 minute, acute teeth; posterior with five. Beaks a little attenuated near the extremity, curved inwards and backwards. Shell thin, with delicate concentric striæ."

This species occurs with C. iowensis, in shales below congl. I.

Ctenodonta (Nucula) houghtoni, Stevens?

(Plate V, Fig. 17.)

A small species collected by Mr. Deming, in the shales over congl. II. is very like N. ventricosa, H.

Shell small, transversely sub-oval; height equal to ⅔ the length;

beaks rather prominent, incurved, situated over ¼ from the front margin; ventral margin rather evenly curved; posterior margin elliptical; anterior margin curved abruptly below, but passing by a nearly straight line to meet the produced hinge at nearly right angles. The escutcheon is well defined by a strong post-umbonal ridge; lunule well-marked. Greatest convexity near the middle; surface covered with fine, close lines of growth. Length 10 mm; height 7 mm, thickness 4.5 mm. The state of preservation forbids positive identification.

Nuculana (Leda) spatulata, sp. n.

(Plate IX, Fig. 11, (12?) Plate VII, Figs. 35.)

Shell elongate oval, broadly expanded anteriorly, acute behind; beaks small, slightly prominent, acute, about seven-twentieths the entire length from the anterior margin; hinge-line rather strongly concave; teeth (if present) small; anterior margin forming a bold, uniform curve, reaching nearly as high as the beaks, with its greatest anterior projection above or near the middle; lower outline gently convex, nearly attaining the hinge posteriorly, but separated from it by a short truncate posterior margin. Greatest convexity about one-third the height of shell from the beaks; umbonal ridge with a sudden, but gentle slope. The surface is marked by very numerous, fine lines of growth—about six occupying the space of 1 mm, in the shells measured. Length [1] 20, [2] 17, [3] 16.5; height [1] 9, [2] 7, [3] 8; distance from beak to front [1] 4, [2] 3, [3] 3; height of beak above longest transverse axis]1] 7,]2] 6, [3] 5. From Leda bellistriata of the coal measures, which it greatly resembles, it differs in being more expanded anteriorly, and having the most convex part of the anterior margin higher than the middle. Shales below congl. I. It is possible that this is Dr. Stevens' species, if so, however, its identification in the coal-measures must be regarded as erroneous.

Nuculana (Leda) similis, sp. n.

(Plate IV, Fig. 15.)

Shell large size, elongate, twice as long as high, rather flat; beak

quite acute, rather prominent, curved anteriorly, about two-fifths the entire length from the front, hinge-line gently curved posteriorly, with about ten teeth; anterior margin a gentle curve with the focus in the lower margin in front of the middle; lower margin nearly straight behind, curving more rapidly as it approaches the front; posterior part of the shell narrow; the greatest elongation anteriorly is near the juncture of the lower and anterior margins. Judging from the cast the shell was very thick, no markings being preserved. Length 25; height 12; width 5-6 (?); beak to front 9; height of beak above longest axis 6 mm.

This is apparently the species identified by Prof. Hall [Pal. N, Y. Vol. V.] with N. pandoriformis, Stevens. The original description of Dr. Stevens seems, however, to forbid the reference.

Nuculana (Leda) saccata, Win.?

(Plate IX, Fig. 12.)

A single poor specimen from the same horizon as the above bears at least a superficial resemblance to the species quoted.

Palaeoneilo ellipticus, sp. n.

(= *Palæoneilo concentrica*, authors, not *cardinia concentrica*, Winchell.)

Shell moderately thick, probably gaping somewhat behind, strongly and evenly convex; outline nearly perfectly elliptical; hinge line extending in front of the beaks, convexly curved posteriorly and concave in front; about twelve oblique teeth in front and about twenty behind; beaks about one-third to three-fourths the length from the front margin, incurved to near the mediam plane; umbo moderately prominent, post-umbonal slope convex, parallel to the hinge-line; preumbonal slope very steep, the umbonal ridge being concave upwards; lower margin a uniform shallow curve; anterior and posterior outlines strongly and similarly curved. Surface of valves marked by few, distant, very prominent concentric ribs, the intervals being flat or con-

cave, and finely striate. About twelve of the ribs are found on a shell of moderate size. Greatest convexity above the middle.

Length.	Height.	Be'k fr'm anterior.	Heig't at ⅓ from post.	Width.	Number of ribs.	Length to height.
23	12	7	10	8(?)	12	2–1
24	14		12		12	1.7–1
22	11	7	10	5–6(?)	11–12	2–1
16	8	5	7	—	10	2–1
18	10	5	9		10	1.8–1
21	12	6	10		12	1.7–1
11	6.5	3	5.5	4	6–8	1.6–1

Three varieties may be recognized by the character of the striations and these seem to be independent of size and may be worthy of specific distinction, though intermediate gradations connect them. One variety.

Var. plicatella

has coarse folds or ribs separated by wide intervals. A shell 13 mm. long and 8 mm. high, has only eight costæ. The youngest specimen seen is only 5 mm. long and 3.5 high and had but five or six costæ.

Var. elegantula

does not differ in proportions or hinge structure, but a shell 14 mm. long and 9 mm. high, has twenty costæ. A larger specimen 29 mm. long and 15 mm. high, has about 25 ribs.

Var. allorismiformis

has the beaks a little, farther forward and the intermediate striolations are nearly equal to the costæ, causing the shell to resemble allorisma. This species has given us much trouble. All the varieties herein described possess the hinge characters of Palæoneilo, which Cardina concentrica is said by Winchell, emphatically, not to possess. Nevertheless, specimens of the present species, which failed to exhibit the teeth, were regarded by Prof. Winchell as Cardinia concentrica. Either there is a species in Michigan exactly like ours, but without the teeth or in the examination of hundreds of specimens we have not hap-

pened upon a typical example of Cardinia concentrica. Many states of preservation conceal the teeth, but in every case the form and characters could be exactly duplicated in specimens with the hinge so broken as to reveal their casts. This species labeled by Meek Palæonilo concentrica, Win., indicates the prevailing opinion in Ohio as to the state of the case, yet, for the present, it may be well to apply a a new name devoid of ambiguity. The species ranges from the shale below congl. I, to the concretionary lime-stones and sandy layers 40-50 feet below. The young are short and muculiform with few teeth.

Note.—Palœoneilo truncata H., is the species described by Winchell as Sanguinolites marshallensis. Hall states that the interior was not seen. Fig. 43, of Plate L, Pal. N. Y., Vol. V, Part II, referred to P. sulcateria, Con., is probably the same, though unusually short.

Palœoneilo sulcateria, Con., is regarded as a synonym for P. barrisi, W. and W., Nucula hubbardi, Win., and L. nuculiformis, stevens. This we have failed to identify or have regarded as an extreme variation from P. elliptica. Hall's figures, stated to have been drawn from Ohio specimens in part, agree with the last named species.

Palaeoneilo attenuata, H.

(Plate IX, Fig. 25.)

Shell very thin, nacreous; valves slightly gaping behind, compressed, equal; outline subrectangular, produced posteriorly, hinge-line straight, extending scarcely forward of the beaks, with many minute teeth in two series, which are not in the same straight line at their union under the beaks, ligament apparently external; anterior margin strongly and evenly curved, extending nearly one-fourth the entire length forward of the beaks; lower margin very slightly convex, somewhat concave at a point about one-third the length from the posterior extremity; posterior margin acutish, the lower margin curving slowly upward until by an abrupt flexture it approaches the upper or hinge margin; greatest thickness about half the height, situated about one-third the distance from beak to front; a shallow depression passing from the slight sinus of the front margin toward but not to the beaks, dorsal part of shell with an abrupt descent to hinge, forming a very narrow but abrupt umbonal slope, generally also an umbonal ridge nearly parallel to the hinge; beaks small, approximate, extend-

ing above the hinge line, anterior umbonal slope steep, a short but well-defined lunule, surface marked only by fine, crowded, concentric striæ. Typical measurements as follows:

	Length.	Height.	Height at ⅓ from posterior margin.	Thickness of both valves.	Distance of umbo from anterior.	H'ight to length.
(1)	25	11	8	5.5	7	1:2.27
(2)	24	10	8		5.5	1:2.40
(3)	39	16	12		10	1:2.43
(4)	18.5	8	6		5	1:2.31
(5)	26	11.5	8		7.5	1:2.26
(6)	24	10	8		6	1:2.40
(7)	29	13	9		8	1:2.23
(8)	27	12	9		6	1:2.25
(9)	29	12.5	11		7	1:2.32
(10)	17	8	6		5	1:2.12
(11)	12	6	4.5		3	1:2
(13)	12	5.5	4		3.5	1:1.118
(14)	10	5	3.5		3	1:2

Numbers 10–14 are small specimens with slightly different characters. The lower margin is straight and the proportional length is less, while the convexity of the surface is more uniform. All the specimens are derived from the shale below the congl. I, and this species is so abundant and constant that it forms a valuable index to this horizon. It is known from many localities. The form is quite like Nuculana, but Prof. Winchell says: "This has the aspect of Ctenodonta hubbardi, Win., but is too thin and rather too much attenuated behind. However, I have thin specimens from Holland, near Lake Michigan."

Arca ornata, sp. n.

(Plate IX, Fig. 18.)

Shell small; rather convex, beaks near the anterior third, acute posteriorly, hinge short. Rather convex near the beaks, which are prominent and incurved; lower line nearly straight, as long as the greatest length of shell; anterior margin slightly curved or nearly straight, intersecting lower line by a sudden curve; posterior outline obliquely truncate forming at the lower angle a regular acute curve; hinge short, inclined toward the posterior ventral angle; anterior umbonal ridge high, the slope making a strong angle with the surface of the valves; post-umbonal ridge near the hinge. Surface marked by

rather distant concentric striæ and posteriorly by thread-like elevated radiating striæ. In general appearance this shell is very like *Macrodon delicatus* of the coal-measures, but differs from all species of Macrodon or Parallelodon in having the greatest length near the ventral line and the lower angles extended and acute. The markings distinguish it from any species of Arca of the Waverly. Length 18 mm; height nearly 8 mm; beak distant from anterior about 6 mm. Other broken specimens indicate that this species reaches a considerably greater size and that the entire surface, when preserved is covered by the fine but distinct radiating thread-like striæ.

Genus Gonoidon, Gen. n.

(*Gonia*, an angle; *odous*, a tooth.)

This name is proposed with some hesitation to receive a nuculiform shell seeming to differ in hinge structure from any genus of the Palæozoic era.

Shell equivalve, very unequilateral, gibbous, not gaping; resembling Palæoneilo, but the hinge is continuous, slightly flexed beneath the beaks, without true teeth, (?) but the hinge margin of both valves zig-zagged by sharp incisions into which corresponding projections of the opposite valve fit closely. The series of denticulations thus formed is continuous, but the size of the excisions diminishes before and behind the beaks. Posterior adductor scar nearly terminal.

Goniodon ohioensis, sp. n.

(Plate XII, Figs. 23, 24, 25.)

Shell closely resembling Palæoneilo; of medium size, very tumid, umbo prominent, incurved. The outline is oblong-elliptical, lower margin nearly straight, posterior extremity rather acutely rounded, anterior extremity short, abruptly rounded; hinge-line equal to nearly two-thirds the entire length, about twelve angulations behind the beak and six to eight in front; ligament apparently below the beaks, not disturbing the continuity of the series of angulations. The greatest convexity is near the umbo. Surface marked by fine reg-

ular concentric striæ. Length 14 mm; height 9.5 mm; thickness 8.5 mm; beaks 4 mm. from front.

This species was collected by W. F. Cooper, in the nodules and shale at the lowest exposure at Moot's run, 4 miles west of Granville. Although suggesting the genus Palæoneilo strongly we do not see how the hinge characters here described can permit this species to fall into any known genus.

Pholadella newberryi, H. and W.

(Plate III, Fig. 27; Plate IV, Fig. 4.)

Shell large, elongated, rather flat, more than twice as long as high, very short anteriorly, produced and rather narrow posteriorly. The lower margin is nearly straight, being rather abruptly curved anteriorly and more gradually posteriorly where it is produced to form an acute angle; posterior margin oblique, forming with the upper a very large angle; hing-line concave, shorter than the length of shell; the anterior margin short, nearly straight; umbones very prominent, beaks incurved over the hinge-line; post-umbonal ridge quite prominent, curved and becoming less distinct to its intersection with the lower posterior angle; post-umbonal slope quite abrupt near the beak, but becoming less so posteriorly; anterior to this ridge the surface is marked by numerous radiating thread-like striæ, which seem almost to lie upon rather than to form a part of the shell; these striæ abruptly cease at a point on the lower margin one-fifth the length from the anterior; shell otherwise covered by strong concentric lines and folds of growth. Prominent characters are the prominent and elevated umbones with the concave hinge line, oblique posterior margin and radiating striæ.

Length 90 mm; height at beak 35 mm; height posteriorly 30 mm; beak distant from anterior margin 13 mm.

Our specimens are apparently little distorted and are much (⅓) larger than those figured by Meek from Rushville. There can be no doubt of the identity, but our specimens show Meek's types to have been much more distorted than Meek's P. (Sedgwickia?) obliqua proposed for the fragment figured. The species is apparently restricted to a rather narrow zone below the shale immediately underlying congl.

II, and above the free-stone proper or in its upper sandy layers. All our specimens being derived from Union Station and Granville.

GASTEROPODA.

Loxonema yandellana, H. (?)

(Plate VIII, Fig. 23.)

The fragment referred to this species agrees with the figures of the Spergen Hill form quite nearly, except in the presence of a well-marked sutural band, which may after all be due to the state of preservation. It is possible that the portion figured is only the upper part of the spire of a larger species. Most of our specimens do not preserve surface markings and can not be safely identified.

Cyclonema leavenworthana, Hall.?

(Plate I, Fig. 20)

This beautiful shell occurs in the upper part of the freestone near Granville, and differs in no respect from those described from the Spergen Hill limestone. From Murchisonia, some species of which it resembles closely, it differs in the absence of a peripheral band, the six volutions being marked only by thread-like revolving striæ. Our specimen is perhaps rather more slender than the types.

Pleurotomaria (Cyclonema?) strigillata, sp. n.

(Plate I, Fig. 10, Plate II, Fig. 25.)

Very similar to Cyclonema lyrata, Hall. Spire moderateiy elevated, composed of from two to four whorls, which are distinctly tricarinate below, but bicarinate above. The whorls increase rapidly, the body whorl being about one-fourth the entire height. The lower whorl is marked by rather distinct crowded incremental lines, which arch sharply backward in passing over the median carina, indicating that the aperture was probably notched. The two accessory carinæ are nearly as strong as the median one. The whorls are quite convex

but are flat or even concave between the carinæ, being evenly rounded below to the apparently small umbilicus. Aperture unseen, apparently sub-circular. Height 16 mm; width 14 mm; height of first volution 9 mm, distance between the upper and median carinæ, 3 mm. The condition of our specimens makes it difficult to distinguish them from the Hamilton species quoted. Frequent in the upper parts of the freestone.

Since the above was written some very perfect specimens have been secured from Moot's run (see Plate XII, Fig. 39.) The species therefore may be regarded as ranging upwards into the freestone and not properly belonging there. From Cyclonema lyrata this form differs in lacking the revolving striæ on the lower surface of the whorls. Casts of the interior found in situ, show Fig. 15, of Plate I, to be such a condition of the present species.

Murchisonia quadricincta, Win. ?

(Plate II, Fig. 28.)

The numerous specimens are all casts in poor preservation, hence the reference is of the nature of a suggestion simply based on a general resemblance. Prof. Winchell informs me that the species has hitherto been only identified in Iowa.

Naticopsis ? sp. n.

(Plate XII, Fig. 37.)

Lack of time prevents a study of this interesting species. It is not certain that this is not a species of Strophostylus resembling S. varians, but is probably nearer to Naticopsis comperta.

Enomphalus latus, H. ?

(Cf. E obtusus, H.)

(Plate XII, Fig. 26.)

Our only specimen is very imperfect, making it impossible to ascertain with certainty its characteristics. The upper surface of the

volutions is concave, the outer margin is distinctly angled, and there is apparently an inner carina at the suture line. The under surface is evenly convex, widely umbilicate. The spire is slightly elevated, but is poorly preserved. The lines of growth are irregular. Our own opinion is that the present form is intermediate between E. obtusus and E. latus. The figure has been partly restored and must not be too implicitly trusted except for size and general configuration.

Free-stone layers of middle Waverly, 6 miles northwest of Granville. Collected by W. F. Cooper.

Euomphalus (spirorbis, H. ?)

(Plate II, Fig. 33.)

(Fig 33b is quite incorrect, the appearance of a lip is misleading and the spire is rather higher. The specimen having been since removed from the matrix these errors have been detected.)

No opportunity has been afforded to compare with Hall's *E. spirorbis* hence our reference is based solely on memory. Shell small, elevated, closely coiled, umbilicate, having from four to five volutions. Volutions rather evenly convex, deeply excavated above for the superior volution, otherwise nearly circular in section Height nearly equal to the diameter of the largest volution.

Height of four volutions 7 mm; diameter of lower volution nearly 9 mm. Free-stone middle Waverly. This species reminds one of E. spergensis, var. planorbiformis, but the spire is higher.

Bellerophon cyrtolites, Hall.

(Plate VIII, Fig. 20; Plate IX, Fig. 29.)

Shell of medium size, laterally somewhat compressed, obtusely carinate; whorls very rapidly enlarging, slightly embracing, transverse section rhombic, sub cordate, broadest near the umbilicus; dorso-lateral slope flat or somewhat concave peripherally, strongly curved near umbilicus; umbilicus rather small. Aperture sub-cordate with a deep but not abrupt, acute notch.

Surface marked by numerous sharp geniculate or strongly curved transverse striæ meeting on the dorsum with an acute angle. Besides

these, well-preserved specimens show less distinct revolving striæ upon the sides, especially near the umbilicus.

We have experienced much difficulty in identifying our Bellerophons. This species is poorly represented and very variable. The form which is referred with confidence to B. cyrtolites, is found in the shales below congl. I, and is about the size of the species quoted. The form is exactly as in the Illinois types. Very careful examination is necessary to discover the revolving lines; 13 is the maximum observed diameter.

A larger form occurs in the shales below congl. II in which the concavity of the sides is more marked, as also the abruptness of the descent to the umbilicus. These are all in the form of casts preserving impressed lines of growth; 22 mm. is a common dimension for the greatest diameter. Above congl. II, in a blue friable shale, specimens more like the type are again found.

The second variety has been collected at Newark, Rushville and Granville, and has been discriminated as *B. cribristriatus.*

There are from 6 to 10 striæ in the space of one-tenth inch near the aperture Dorso-ventral diameter of aperture perhaps 12-15 mm, transverse diameter 10-12.

Bellerophon galericulatus, Win.

(Plate IX, Fig. 32.)

"Shell small, globose, involute, carinate, ex-umbilicate, longitudinally striate, and deeply notched. Dorsum broadly and regularly rounded, without any evidences of a band except in approaching the aperture of adult shells, where a rather broad band, with ventrally concave incremental lines can be faintly traced, Aperture crescentic, not suddenly expanded, strongly auriculate, with the ears hanging detached from the inner whorl. Notch infundibuliform, deep and broad, obtuse, its sides reaching the tips of the auriculations. Umbilicus closed, scarcely indented. Dorsal and dorso lateral surface marked by about 28 longitudinal, sharply raised striæ, separated by much wider flutings and not perceptibly modified by dorsal band until within half of a whorl of the aperture of the adult shell, when the two middle striæ become slightly raised and enlarged and the entire set simultaneously die away. Between these striæ and the umbilical point sim-

ilar striæ diverge spirally and irregular[ly] until intercepted by the former set or by each other. Cast smooth, perforately umbilicate. Average diameter of adult .47 (100); height of last whorl at the aperture .26 (55); height of aperture .18 (38); showing the inner whorl impressed into outer .08 (17); width of aperture .35 (74); depth of notch .22 (47); width of peripheral belt at notch .06 (13); separating distance between tip of auriculations and inner whorl .10 (21); number of striæ in 1-10 in. .10 (in young and old) largest seen diameter of .53." Bellerophon galericulatus is quite common in the shales four feet below congl. I.

Bellerophon, sp?

(Plate XII, Fig. 36.)

A species with decided Devonian affinities is illustrated from the nodules at Moot's run. It is sufficiently distinct from any of the above species, but we have no time to study its relations with Devonian species.

Bellerophon perelegans, M. and W.?

(Plate IX, Fig. 30.)

"Shell small, subglobose; umbilicus small, aperture transverse, reniform. Back and sides marked by fine, sharply elevated revolving lines, which are about equal to the spaces between them, finer and more closely arranged in the middle than on the sides of the shell. Dorsum marked by a narrow, elevated, revolving band, bounded on either side by a shallow depression. The revolving lines on the band are much finer than those on the body of the shell. Very fine striæ of growth cross the revolving striæ, giving a finely cancellated appearance to the surface. Margin of the peristome nearly straight or with a gentle backward curvature to the shallow central notch."

Our knowledge of this species is confined to fragments of several individuals with tolerably constant characters. The band, except near

the peristome, is rather concave, the transverse striæ are more regular and often more conspicuous than the revolving, otherwise the agreement is close. With B. galericulatus, 4 feet below congl. I.

Genus Platyceras.

Of this genus six species are reported by Prof. Winchell from Ohio, viz: P. bivolve, P. haliotoides, P. hertzeri, P. paralium, P. romerium, and P. subplicatum.

Platyceras hertzeri, Win.

(Plate II, Fig. 24, and Plate V, Fig. 8.)

The difficulty of distinguishing the variable species of Platyceras rather increases than diminishes with the accumulation of specimens. The present species, which may be recognized by its moderately large size and irregularly plicate, nodulose surface, and compressed form extends from the free-stone into conglomerate II. There is generally a poorly defined carina near the outer margin as well as irregular transverse plications. From P. haliotoides it is distinguished by the less closely coiled spire.

Platyceras haliotoides, M. and W.

(Plate II, Fig. 23.)

Our figure illustrates a small and not particularly characteristic specimen. Many specimens agree fully with the Illinois types, while others pass toward P. hertzeri. The upper surface is convex, with only a very faint revolving groove or none, the outer surface being narrowly rounded, the aperture very oblique. From P. hertzeri it may also be distinguished by the closely incoiled spire. With the last.

Platyceras bivolve, M. and W. ?

A single specimen is doubtfully identified with this species.

Quite small, very ventricose, composed of (less than) two closely coiled rounded volutions; spire not elevated; inner whorl minute, outer whorl very rapidly expanding, ventricose, expanding especially downward; section of volution broadly ovate, broadest externally; aperture with a faint sinus on the upper and lower external aspects. With the last.

Platyceras sp. Cf. *P. paralium,* M. and W.

(Plate I, Fig. 23, (Fig. 22?)

We have a few specimens resembling *P. paralium*, which differ from the above in having a well-defined revolving ridge and groove of the upper surface. The spire is minute and the aperture not very oblique. With the above.

Dentalium granvillensis, sp. n.

Closely related with *grandævum*, Win.

Shell large, straight, oval in section; tapering about .078 in one inch, marked except near the aperture by fine thread-like striæ which cross the surface nearly at right angles and are more or less regular. Casts are nearly perfectly smooth. This species most nearly resembles D. canna, but is always oval in section. The striæ nearly seem to cross the shell at right angles and on well-preserved specimens are strong and elevated. No evidences of longitudinal markings were seen. The length may have exceeded 8 cm. The longest fragment measures 49 mm. The longer diameter at the apertural end is 9 mm, at the apical 5 mm; another 50 mm. long measures aperturally 10 mm, apically 6 mm, or about 8 mm contraction per cm. D. grandævum is said to expand more rapidly, but may not prove distinct.

Free stone at Granville.

Goniatites lyoni, M. and W.

Fragments apparently indistinguishable from this species were col-

lected in the free-stone of middle Waverly at Granville. The types were from the Goniatite bed of the Kinderhook group, a zone certainly embraced within the limits of our Waverly.

Another and apparently distinct species is characteristic of the upper layers of division III. See Plate VII, Fig. 27.

Conularia newberryi, Winchell.

(Plate VI, Fig. 13; Plate VIII, Fig. 9; Plate II, Fig. 18?)

This species as quoted by Meek (O. Pal. Vol. II, p. 316), was wrongly attributed to Hall. It was described by Winchell. [Proc. American Philos. Soc., July, 1865, p. 130.] The original description was written from a small fragment and gives an imperfect idea of the species as a description of a specimen merely always does.

"Shell very small, in the form of a quadrangular pyramid. The pyramid is inclined over one of the angles. Angles of the pyramid slightly rounded and marked by a shallow groove running longitudinally. Each side is marked by sharp raised transverse lines, which instead of running directly across, are angulated in the middle, so that at this point they are nearer the base of the shell by a distance equal to once and a half the distance between two lines. The distance between the lines increases from above downwards and is everywhere equal to about one ninth of the width of the side. These transverse lines have the appearance of the projecting edges of septa, and are continuous from the middle of one of the shorter sides of the pyramid around to the same point, though the ends do not join, but are alternate in position. The sides of the pyramid are inclined at an angle of about 30°." The fragment, about one-half inch long, had a basal diameter of .17. Cuyahoga Falls, O, in water limestone, below the conglomerate. Prof. Winchell reidentifies this species from bed 4. Sciotoville, O. [Proc. Am. Philos. Soc., Vol. XII, Jan. 4, 1870, p. 258.] "The species appears to have been at least three or four inches in length; the septa range from 17-44 to the inch; it bears a V-shaped furrow along each of the angles, within this furrow the septa are deflected abruptly toward the base of the shell, so that they meet from opposite sides about at a right angle; the septa also sweep toward the base with a gentle curve in their extension across the side of the pyramid, by which their centres are about two intervals lower than the por-

tion of the ridge which bounds the angular furrow. The septa are ornamented along their margins by delicate granulations."

Mr. Meek's figure and description, being drawn from a very imperfect specimen, add nothing to the above and hardly serve to identify the species. The specimen figured upon Plate VI, is from the lowest horizon, coming from the same bed as Spirifer marionensis. It is remarkable for the slight angle at which the sides converge toward the apex and the strictly quadrangular section. One face measures 15 mm. transversely, the other 12 mm. at the aperture, which shows the presence of deep sinus at the angles, while the faces from the inclined flaps long since indicated as a character of the genus. The angle made by the sides is less than 10°. There are twelve transverse striæ in one centimeter or about 15 in half an inch near the aperture. These striæ exhibit distinct pearling upon their summits, the minute pustules being rather distant from each other. The length may have been three or four inches unless more rapidly tapering above.

Other specimens from the shale below congl. I, are apparently identical. In the free stone the same species appears, though our specimens indicate a more obtuse spire and are not in a condition to exhibit the ornamentation. In the shale below congl. II, specimens of larger size but similar characters occur. Finally, small specimens from the Cuyahoga shale are decidedly of the same type Neither do we know how to distinguish the form found in the lower shales of the coal-measures, though the crenulations have not been seen. None of these show any traces of the barred longitudinal markings of *C. byblis*, W., *C. missouriensis*, as identified by Meek and Worthen, has coarser and more distant striæ.

Conularia micronema, Meek.

(Plate II, Fig. 19.)

"Shell elongate-pyramidal, with the sides equally diverging from the apex with an angle of about sixteen degrees ; lateral surfaces nearly flat, and without any mesial furrow [sic] but sometimes showing a very faint, slender mesial ridge, which becomes nearly or quite obsolete toward the smaller end ; each of the four angles a little rounded and provided with a shallow, moderately distinct longitudinal furrow. Surface with numerous extremely small, closely crowded transverse

striæ, of very nearly the same size on all parts of the shell; striæ gently arching forward as they cross the side, and scarcely interrupted at the little mesial longitudinal ridge, minutely crenate, and separated by extremely slender linear furrows, numbering fifteen in the space of one-tenth of an inch on all parts of the surface; crenulations of striæ twelve to fifteen in one-tenth inch."

Length apparently about 3 inches.

Compare *O. subcarbonaria*, M. and W.

Conularia byblis, White.

Conularia byblis, White, Proc. Bost. Soc. N. H., Vol. IX, p. 22. "Shell large, in the shape of a truncated pyramid, length twice (?) the width at the base, apex broadly rounded, smooth, sides depressed, convex; grooves at the angles narrow, a faint longitudinal depression, along the middle of each side; transverse ridges narrow, distinctly raised, forty-five or fifty to the inch, but slightly curved in passing from the salient angles to the faint central depression, at which they meet at an obtuse angle and cross with slight interruption; sometimes, however, they alternate for a short distance and then cross continuously as before. Spaces between the ridges finely crenulate. Chemung beds at Burlington, Ia." Winchell states further that there are small granulations ranged in a line along the crests of the ridges, 60–75 of which occupy the space of an inch. He refers the "crenulations between the ridges" to transverse bars developed between the ridges in worn specimens. The septa range from 56–128 to the inch. The septa-margins trend toward the base, but they are more nearly straight from angle to centre than C. newberryi. Winchell's specimens come from dark bituminous shales. Hickman Co., Tenn.

This form has not been encountered in Licking county, but is quoted for reference.

Stictopora striata, Hall.

(Plate XII, Fig. 40.)

Beautifully preserved and abundant specimens of a Stictopora are found in the nodules at Moot's run, and these can not be distinguished with the time at disposal from the Hamilton species quoted. Several

other species associated in this horizon await a better opportunity. We reproduce part of Prof. Hall's description. "Zoarium consisting of a flattened, dichotomously branching frond arising from a spreading base. Branches 3–4 mm; margins sometimes parallel, at others slightly diverging, the greatest increase in width in a length of 15 mm. being 1 mm; non-celluliferous marginal space narrow, width .15 mm, not flat; transverse section regularly convex on the two sides, greatest thickness .50 mm; bifurcations comparatively distant, branches diverging at an angle of 60° or more. Cells tubular, for the greater portion of length very oblique, often nearly parallel to the mesotheca, then turning and opening obliquely to the surface, on the narrower portion of the branches often recumbent for nearly the entire length. * * *. Cell apertures very broadly oval, often circular, sometimes pustuliform, disposed in somewhat irregular longitudinal rows, but the rows being very close together and the apertures being separated by more than twice their diameter, the arrangement is indistinct; they sometimes alternate and form oblique transverse rows and often irregular, direct transverse rows. Marginal apertures very little if at all larger than the others. Peristomes moderately thick, strongly elevated, smooth; interapertural and marginal space striated, striæ short, tortuous, interrupted."

While some doubt may still exist as to the identity of our species with the above, its Devonian affinity is obvious.

Addenda.

[*To Page* 65.]

Schizodus [*Protoschizodus*] *palaeoneiliformis*, sp. n.

(Plate XII, Fig. 44.)

Six specimens found since the above was printed present concordant characters.

Of small size, sub-nuculiform, produced behind, equivalve, length to height as 23 to 15. Beaks less than one-third the length from the anterior; hinge somewhat over half to nearly two-thirds the total length; anterior margin short, broadly rounded, passing gently into the very slightly and uniformly curving lower margin, which meets the

acute posterior angle at a point below half the height; posterior margin slightly concave, inclined to the longitudinal axis about 40°, making an angle of about 150° with the declined hinge margin. Greatest convexity of valves near the beak, from which a strong post-umbonal ridge passes to the posterior angle, above which the surface is concave; entire surface marked by fine thread-like, closely arranged striæ. Although our specimens are rather strongly produced and the interior could not be seen there is little doubt of the generic reference.

Length 24 mm. (19–17); height 15 mm. (11–10.) Freestone of middle Wavery, Union Station. W. F. Cooper collector.

This species may be compared with *Sch. nuculiformis* or *Sch. obscurus*, Dekoninck.

Conocardium pulchellum, White and Whitfield.

(Plate I, Fig. 12; Plate VII, Fig. 39, Fig. 40?)

"Shell small, general form triangular, with ventricose valves. Hinge line straight, the length equal to that of the posterior slope. Anterior end cuneate; posterior end obliquely truncate. Basal line gently arcuate, widely gaping near the anterior extremity; hiatus elongate ovate, distinctly crenulate on the inner border. Beaks minute, incurved, situated posteriorly; umbonal slope rounded, posterior space concave; siphonal tube small. Entire surface marked by distinct, diverging radii, those of the posterior space a trifle finer than those of the body of the shell; also by very fine concentric striæ. Greatest length .4 inch."

Identified from Newark by Winchell. (Am. Philos. Soc. Vol. XII, p. 256.)

It seems to be common at Granville, also, in the free stone of middle Waverly.

Another species is represented, but is known only from distorted specimens. (See Fig. 41, Plate VII.)

NAME.	OHIO. I	II	III	ILL.	ELSEWH'RE.	REMARKS.
Phillipsia meramecensis			o		Missouri.	Archimedes.
Phillipsia shumardi		o			"	Chouteau.
Phillipsia præcursor	o					sp. n.
Pleurodictyum problematicum		o		o	Europe.	Devonian.
Orbiculoidea sp		o				
Crania hamiltoniæ	o					Devonian.
Productus nebrascensis		o	o			Coal-meas. sp.
Productus semireticulatus		o	o			"
Productus arcuatus			o		Iowa.	
Productus burlingtonensis			o		"	Sub-carb.
Productus shumardianus	o				"	Devonian.
Productus concentricus	o				Michigan.	"
Productus lachrymosus	o				New York.	"
Productus speciosus	o				"	"
Productus gracilis	o			o	Michigan.	"
Chonetes logani	o		o	o		
Chonetes illinoisensis		o	o	o		
Chonetes scitula	o	?				
Chonetes tumidus	o					Devonian affinity.
Chonetes pulchella		o			Michigan.	
Hemipronites crenistria	o	o	o		∞	
Orthis vanuxemi, var		o				
Rhynchonella contracta	o	o			New York	Devonian.
Rhynchonella subcuneata?	o					"
Rhynchonella sageriana	o					
Rhynchonella sappho		o	o		New York.	Devonian.
Rhynchonella marshallensis		o			Michigan.	
Atrypa reticularis		o	?		∞	Devonian.
Syringothyris cuspidatus		o			∞	
Spirifer marionensis	o				Missouri.	
Spirifer striatiformis			o			
Spirifer biplicatus		?				
Spirifer winchelli		o				sp. n.
Spirifer varicosta ?						
Spirifer hirtus		o				
Cyrtina sp	o					
Spiriferina solidirostris		o				
Spiriferina depressa		o				sp. n.
Cryptonella eudora		o			New York.	
Centronella julia		o			Michigan.	
Athyris ohioensis		o				
Athyris lamellosa	o					
Aviculopecten perelongatus		o				sp. n.
Aviculopecten grandvillensis		o	?			sp. n.
Aviculopecten sp. (p. 51.)			o			
Aviculopecten cooperi	o					sp. n.
Aviculopecten oweni ?		o				
Crenipecten newarkensis		o				
Crenipecten subcardiformis	o					sp. n.
Crenipecten senilis		?				sp. n.
Lyriopecten ? cancellatus	o					sp. n.
Limatulina ? ohioensis			o			sp. n.
Streblopteria media	o					sp. n.
Streblopteria squama	o					sp. n.

NAME.	OHIO. I	II	III	ILL.	ELSEWH'RE.	REMARKS.
Streblopteria gracilis		o				sp. n.
Pernopecten shumardiana	o					
Pterinopecten cariniferus	o					sp. n.
Pteronites obliquus	o					sp. n.
Leptodesma scutella	o					sp. n.
Posidonomya fragilis	o					sp. n.
Promacra truncata	o					sp. n.
Leiopteria ortoni	o					sp. n.
Leiopteria halli		o				sp. n.
Leiopteria sp	o					
Leiopteria sp		o				
Myalina michiganensis		o			Michigan,	
Modiola waverlyensis		o				sp. n.
Schizodus newarkensis			o			sp. n.
Schizodus chemungensis		o			New York.	
Schizodus cuneus		o				
Schizodus medinaensis		o				
Schizodus palæoneiliformis		o				sp. n.
Orthonota rectidorsalis	o				Michigan.	
Prothyris meeki		o				
Sanguinolites senilis	o					sp. n.
Sanguinolites marshallensis		o			Michigan.	
Sanguinolites unioniformis	o				"	
Sanguinolites transversus	o				∞	
Sanguinolites contractus	o				∞	
Sanguinolites flavius	o					
Sanguinolites amygdalinus	o				Michigan.	
Sanguinolites michiganensis		o			"	
Sanguinolites aeolus		o				
Sanguinolites obliquus		o				
Sanguinolites naiadiformis	o	o			Michigan.	
Allorisma nobilis		o			Belgium.	
Allorisma cooperi		o				sp. n.
Allorisma winchelli		o				
Allorisma ventricosa		o				
Allorisma convexa		o				sp. n.
Macrodon ? triangularis		o				sp. n.
Microdon reservatus		o				
Grammysia rhomboides		o				
Grammysia hannibalensis		o				
Grammysia ventricosa		o				
Grammysia ? sp	o					
Modiomorpha hyalea		o				
Edmondia depressa		o				
Edmondia burlingtonensis	o					
Ctenodonta iowensis	o				Iowa.	
Ctenodonta stella	o				Michigan.	
Ctenodonta houghtoni ?		o				
Nuculana spatulata	o					sp. n.
Nuculana similis	o					sp. n.
Nuculana saccata	o				Michigan.	
Palaeoneilo elliptica	o				?	sp. n.
Palaeoneilo plicatella	o					sp. n.
Palaeoneilo elegantula	o					sp. n.

NAME.	OHIO. I	II	III	ILL.	ELSEWH'RE.	REMARKS.
Palaeoneilo allorismiformis	o					
Palaeoneilo attenuata	o					
Arca ornata	o					sp n.
Goniodon ohioensis	o					sp. n.
Pholadella newberryi		o			Michigan.	
Conocardium pulchellum		o				
Loxonema yandellana		o		o		
Cyclonema leavenworthana		o		o	Iowa.	
Cyclonema strigillata	o					sp. n.
Murchisonia quadricincta		o				
Naticopsis sp	o					
Euomphalus latus		o				
Euomphalus spirorbis		o				
Bellerophon cyrtolites	o	o		o		
Bellerophon galer.culatus	o					
Bellerophon sp	o					
Bellerophon perelegans	o					
Platyceras hertzeri		o				
Platyceras haliotoides						
Platyceras bivolve		o				
Platyceras paralium ?		o				
Dentalium granvillensis		o				sp. n.
Goniatites lyoni		o				
Goniatites			o			
Conularia newberryi	o	o	o			
Conularia micronema		o				
Conularia byblis		?				
Stictopora striata	o					Devonian.

If we examine the above table candidly we discover at once that our suspicion that the Waverly is not homogeneous is abundantly substantiated, and not less noticeable is the difference in habitus between these assemblages. The lines chosen as the outlines of our divisions were selected because they mark shore deposits and thus are transition zones, as the deposits of a progressing or retreating littoral zone must always be with regard to the sea-basin deposits formed before and after the fluctuation in level producing the movement. Certainly no other lines will prove more convenient in Licking county, though all such zones may be arbitrary as regards other areas. Now in number I, extending say 100 feet below congl. I, the fauna, as so far worked, presents about the following relations: Species of carboniferous habit, 2 or 3; species with decidedly Devonian habit (often closely related to Hamilton species), 25; species not found outside this zone or if so in horizons still under discussion, 30. In No II, embracing all between congl. I and II, species with carboniferous habit, possibly 9; species with Devonian affinities (often Chemung species) 12; species which

are limited to this horizon or horizons still debated, 45. The division III, requires more study, but at least 7 species with carboniferous habit and 10 with no special bearing are unmixed with a species of Devonian alliances so far as known, except near the base. The evidence here is, it is true, chiefly negative. These conclusions have been reached on as conservative a basis as possible. If there is any error it is rather in favor of the carboniferous tincture in the two lower members.

The tentative conclusions now held are, therefore, as follows: The Waverly group of Ohio is a composite assemblage of lithologically constant character. The lower portion of it is chiefly composed of greyish, yellowish, and greenish, arenaceous shales, with local grits and nodulary masses of limestone, and occasionally near the base intercalated layers of bituminous shale. This series is faunally nearly distinct in Central Ohio and should be regarded not only as Devonian, but as containing persistent elements of the Hamilton types in connection with Portage and Chemung forms. However, it is believed that geographical variation must be called in very largely to explain the specific divergencies, while generic resemblances remain perfectly obvious.

Our division II, although so relatively small, was evidently a transition period. Most of the strata may have been deposited while the Catskill was forming at the east, but the fauna was essentially of Chemung character. Nevertheless the connection in Ohio was much more direct with areas where already carboniferous types were appearing and a more or less marked admixture was the result. Conglomerate II marks a slight oscillatory wave passing perhaps from north to south, resulting first in mud flats in which burrowing mollusks thrived, later in shore-lines kept supplied with pebbles by re-invigorated rivers. When the sea next returned it was with its freight of carboniferous forms, but the old Chemung species had chiefly perished during the slight oscillation. Comparatively few deep-sea forms accommodated themselves to the littoral conditions for a time, but such as did are related with Burlington or Keokuk species, which formations were then accumulating to the westward. It is not difficult to conceive that conditions might exist in Ohio, which would considerably alter specifically, a fauna pretty closely concordant generically with the Chemung in New York. In our second division a number of species are specifically identical with those in New York. Yet we prefer to believe that

the freestones of the middle Waverly in Ohio, lie chronologically somewhat above the Chemung and include the Catskill epoch. The upper member doubtless includes equivalents of the base of the Burlington sandstone. The Cuyahoga shale presents a problem still difficult of solution, but we suspect a surprise awaits geologists when it is carefully studied. It is probable that the black or Ohio shale lies below the horizon of the typical Genesee.

In conclusion, it seems that no better evidence were necessary to convince one of the continuity of animal existence than that here afforded. Not only do rigid lines of stratigraphy break down, but hard and fast specific distinctions are obliterated and we begin to see how the retreating and advancing and ever-varying sea flung the shuttles back and forth, weaving the intricate pattern of historic geology without ever breaking the thread of life or resetting the web. But every new struggle brought out hitherto undeveloped possibilities in life and, instead of perishing, life ever came off victor by virtue of implanted aspiration and the environment of conscious force—God.

NOTE:—After the first portion of this paper was in type, accumulated observations place the stratigraphy of the lower portion of the series on a more definite footing, showing the nodule layer so often mentioned to lie about 40 feet below the horizon of Leiopteria orteni and Crenipecten subcardiformis, and hence between 60 and 80 feet below the congl. I, at Union Station, south of Granville.

PLATE I.

Fig 1. *Spirifer winchelli*, sp. n., small dorsal valve.
Fig. 2. *Spirifer*, sp?
Fig. 3. *Spirifer marionensis?*
Fig. 4. *Chonetes gracilis?*
Fig. 5. *?*
Fig. 6. *Spirifer striatiformis*, var?
Fig. 7. *Syringothyris cuspidatus*, var?
Fig. 8 *Spiriferina solidirostris?*
Fig. 9. *Modiola waverlyensis*, sp. n.
Fig. 10. *Pleurotomaria strigillata*, sp. n.
Fig. 11. *?*
Fig. 12. *Conocardium pulchellum.*
Fig. 13, *Streblopteria media*, sp. n.
Fig. 14. *Ctenodonta iowensis.*
Fig. 15. Internal cast of same species as Fig. 10.

Fig. 16. *Schizodus medinaensis*, imperfect cast.
Fig. 17. *Ctenodonta iowensis.*
Fig. 18. *Aviculopecten winchelli*, right valve.
Fig. 19. *Streblopteria media*, sp. n.
Fig. 20. *Cyclonema leavenworthana* (?)
Fig. 21. *Bellerophon cyrtolites*, compressed specimen.
Fig 22. *Platyceras* sp?
Fig. 23. *Platyceras paralium.*
Fig. 24. *Productus nebrascensis*
Fig. 25. *Schizodus chemungensis.*
Fig. 26. *Productus semireticulatus.*
Fig. 27. Plant stem.
Fig. 28. Crinoidal plate.

PLATE II.

Figs 1, 2, 3. *Spirigera ohioensis?*
Fig. 4. *Centronella* sp?
Fig. 5. *Centronella julia.*
Fig. 9. *Schizoaus medinaensis*, very poor cast.
Fig. 7. *Athyris lamellosa.*
Fig. 8. *Centronella* sp?
Figs. 9 11. *Spiriferina solidirostris.*
Figs. 12, 13. *Rhetzia* sp.
Fig. 14. *?*
Fig. 15. *Rhynchonella sageriana* (= var. of R. sappho?)
Fig. 16. *Spirifer winchelli*, sp. n.
Fig. 17. *Syringothyris cuspidatus.*
Fig. 18. *Conularia.*
Fig. 19. *Conularia micronema*
Fig. 20. *Limatulina ? ohioensis*, sp. n.
Fig. 21. *Chonetes tumida.*
Fig. 22. *Phillipsia shumardi.*
Fig. 23. *Platyceras*, sp.
Fig. 24. *Platyceras*, sp.
Fig. 25. *Pleurotomaria strigillata*, sp. n.
Fig 26. *Nautilus ?* sp.
Fig. 27. *Bellerophon cyrtolites.*
Fig. 28. *Murchisonia.*
Fig. 29. *Bellerophon cyrtolites.*
Fig. 30. *Bellerophon* sp.
Fig. 31. Plant impression.
Fig. 33. *Euomphalus spirorbis?*
Fig. 34. *Bellerophon galericulatus.*

PLATE III.

Fig 1. *Crenipecten senilis*, sp. n , left valve.
Fig. 2. *Spirifer hirtus*, M. and W. ?
Fig. 3. *Platyceras*, sp.
Fig. 4. *Streblopteria media*, small right valve.
Fig. 5. *Aviculopecten* (cf. *Oweni.*)
Fig. 6. *Leiopteria*, sp.
Fig. 7. *Aviculopecten*, right valve.
Figs. 8, 9. *Streblopteria media*, sp. n., left and right valve.
Fig. 10. *Limatulina ohioensis*, n. sp., left valve.
Fig. 11. *Atrypa reticularis?*
Fig. 12. *Hemipronites crenistria?*, young.
Fig. 13. *Chonetes*, sp.
Fig. 14. *Chonetes pulchella*, Win.
Figs. 15, 16. *Nucula*, sp. ?
Fig. 18. *Productus arcuatus*, H.
Fig. 19. *Ostracode crustacean.*
Fig. 20. *Productus flemingi.*
Fig. 21. *Chonetes illinoisensis.*
Fig. 22. *Productus*, sp.
Fig. 23. *Spirifer striatiformis*, (cf. *tullia*, H.)
Fig. 24. *Productella ?*
Fig 25. *Productus nebrascensis.*
Fig. 26. *Spirifer striatiformis*, camera drawing of striae.
Fig. 27. *Pholadella newberryi*, right valve.
Fig. 28. *Productus lachrymosus*, var. *stigmarius*, H.
Fig. 29. *Hemipronites crenistria.*
Fig. 30. *Promacrus truncatus*, sp. n., dorsal view.
Fig. 31. *Aviculopecten newarkensis*, Win. ?
Fig. 32. Hypostome of *Phillipsia shumardi?*

PLATE IV.

Fig. 1. See page 75.
Fig. 2. *Sanguinolites naiadiformis.*
Fig. 3. *Palæoneilo attenuata.*
Fig. 4. *Pholadella newberryi.*
Fig. 5. *Edmondia ?*
Fig. 6. *Myalina michiganensis.*
Fig. 7. *Nucula*, sp ?
Fig. 8. *Grammysia*, imperfect cast.
Fig. 9. *Palæoneilo plicatella*, small individual.
Fig. 10. *Modiola waverlyensis.*

Fig. 12. *Palæoneilo elliptica*, upper figure, var. *plicatella* lower, var. *atlorismiformis*.
Fig. 13. *Grammysia hannibalensis*.
Fig. 14. *Microdon reservatus ?*
Fig. 15. *Nuculana simliis*, cast.
Figs. 16, 17. ?
Fig. 18. *Edmondia burlingtonensis*, ?
Fig. 19. Cf. Fig. 4, Plate IX.
Fig. 20. *Pteronites obliquus ?*

PLATE V.

Fig. 1. *Rhynchonella sappho* (Cf. *coopori*), Congl. II.
Fig. 2. *Spirifer winchelli*, dorsal valve. Congl. II.
Fig. 3. *Spirifer winchelli*, ventral valve.
Fig. 4. *Syringothyris cuspidatus*, front view.
Fig. 5. *Syringothyris cuspidatus*, ventral view of cast.
Fig. 6. *Syringothyris cuspidatus*, hinge view of cast.
Fig. 7. *Syringothyris cuspidatus*, diagramatic median section of ventral valve.
Fig. 8. *Platyceras hertzeri*, cast.
Fig. 9. *Orthis vanuxemi*, var. *pulchellus*.
Fig. 10. *Cryptonella eudora*.
Fig. 11. *Sanguinolites marshallensis*.
Fig. 12, (No. 1367.)
Fig. 13. *Spiriferina solidirostris*.
Fig. 14. *Hemipronites crenistria?*.
Fig. 15. *Schizodus cuneus*.
Fig. 16. Unidentified crinoid from congl. II.
Fig. 17. *Ctenodonta houghtoni ?*
Fig. 18. *Rhynchonella* sp.

PLATE VI.

Fig. 1, *Posidonomya (streblopteria) fragilis*, sp. n.
Fig. 1. *Spirifer marionensis*, ventral valve, Moots' Run, Licking Co.
Fig. 2a. do hinge view of same. Partial cast.
Fig. 2b. do hinge view of dorsal valve, cast.
Fig. 2c. do umbonal region of same.
Fig. 3. do dorsal valve. From concretions of lime 15 feet below horizon of No. 2.
Fig. 3a. do hinge view of same.
Fig. 4. do ventral valve from same horizon.
Fig. 4a. do hinge view of same.

Fig. 5 and 5a. smaller valves of same species.
Fig 6. *Spirifer striatiformis*, dorsal valne. From exposure 1½ miles south-east of Granville.
Fig. 7. do. ventral valve, upper layers at Williams' quarry west of Granville.
Fig. 8. *Hemipronites crenistria*, dorsal valve, with Fig. 2. Moot's Run.
Fig. 9 do. From the freestone. ?
Fig. 10. *Allorisma cooperi*. Union Station freestone.
Fig. 11. *Productus semireticulatus*, dorsal valve.
Fig. 12. *Aviculopecten winchelli*. Freestone.
Fig. 13. *Conularia newberryi ?* 13a. End view.
Fig. 14. *Nautilus ?* sp. Moots' run.
Fig. 15. ?
Fig. 16. *Productus concentricus*.
Fig 17. Front view of Fig. 13.

PLATE VII.

Fig 1. *Leiopteria ortoni*, sp. n., 40 ft below congl. I.
Fig. 2. *Streblopteria media*, left valve. Large var. from about 75 ft. below congl. I.
Fig. 3. do.
Fig. 4. *Crenipecten subcardiformis*, 40 feet below congl. I.
Fig. 5. do.
Fig. 6. *Streblopteria media*, right valve.
Fig. 7. *Pteronites obliquus*.
Fig. 8 *Palæoneilo* sp.
Fig. 9. *Rhynchonella* sp.
Fig. 10.. *Sanguinolites marshallensis*, sp n. (1377.)
Fig. 11. *Spirifer marionensis*. (1361.)
Fig. 12. *Streblopteria gracilis*.
Fig. 13. *Crenipecten* sp.
Fig. 14. *Streblopteria squama*.
Fig. 15. *Chonetes* sp.
Fig. 16. *Spiriferina octoplicata*. ?
Fig. 17. *Euomphalus* sp.
Fig. 18. *Productus shumardianus*, II.
Fig. 19. *Athyris*, sp.
Fig. 20. *Productus gracilis*.
Fig. 21. ?
Fig. 22. *Chonetes logani*, ventral and dorsal valves.
Fig. 23. *Rhynchonella subcuneata ?*
Fig. 24. *Spirifer* sp. Freestone, Granville.
Fig. 25. *Rhynchonella sappho*.

Fig. 26. *Productus*, (cf. Plate III, Fig. 20.)
Fig. 27. *Goniatites* sp ?
Fig. 28. *Aviculopecten*, sp.
Fig. 29. *Modiola waverlyensis*.
Fig. 31. *Leiopteria halli*.
Fig. 32. *Leiopteria* sp. Moot's Run.
Fig. 33. *Allorisma* sp ? (No. 1378.)
Fig 34. *Athyris* sp.
Fig. 35. *Nuculana* sp. 30 feet below conel. I.
Fig. 36. ? do
Fig. 37. *Palæoneilo concentrica* var. do.
Fig. 38. *Platyceras* sp ?
Fig. 39. *Conocardium pulchellum*.
Fig. 40. *Conocardium pulchellum ?*
Figs. 41. *Conocardium* sp ?

PLATE VIII.

Fig. 1. *Sanguinolites acolus*. Shale below congl. II, Newark.
Fig. 2. *Allorisma winchelli*, side view.
Fig 3. do hinge view.
Fig. 4. do front view.
Fig. 5. *Edmondia depressa*, side view.
Fig. 6. *Allorisma ventricosa*, M. do
Fig. 7. *Prothyris meeki*. do
Fig. 8. *Microdon ? triangularis*, Freestone.
Fig. 9. *Conularia newberryi*, below congl. II.
Fig. 10. *Sanguinolites michiganensis*.
Fig. 11. *Sanguinolites acolus*, small specimen.
Fig. 12. *Grammysia ventricosa*, Freestone.
Fig. 13. ? Shale below congl. II.
Fig. 14. *Orbiculoidea* sp. do
Fig. 15. *Pleurodictyum problematicum*, Goldf.
Fig. 16. *Ctenodonta* sp., nodules, Moot's run.
Fig 17. *Cyclonema ?* do
Fig. 18. *Spirifer ?* do
Fig. 19. *Chonetes*.
Fig. 20. *Bellerophon cyrtolites*, H., var. *cribristriatus*, var. n, above Freestone, Granville.
Fig. 21. *Bellerophon cyrtolites*. Shale below congl. II, Newark.
Fig. 22. *Bellerophon* sp ?
Fig. 23. *Loxonema Yandellana*.
Fig. 23. *Chonetes ?* nodules Moot's run.
Fig. 24. *Phillipsia ?* do

PLATE IX.

Fig. 1. *Sprifer marionensis.*
Fig. 2. Unidentified casts from "Dug-way."
Fig. 3. *Sanguinolites naiadiformis.*
Fig. 4. Unidentified.
Fig. 5. *Sanguinolites unioniformis.*
Fig. 6. *Oothonota rectidorsatus.*
Fig. 7. *Sanguinolites unioniformis.*
Fig. 8. do do
Fig. 9. do do
Fig. 10. do *flavius.*
Fig. 11. *Leda spatulata.*
Fig. 12. *Leda saccata.*
Fig. 13. *Palæoneilo elliptica.*
Fig. 14. *Nucula iowensis.*
Fig 15. *Palæoneilo elliptica,*
Fig. 16. *Nucula ?*
Fig. 17. *Edmondia burlingtonensis ?*
Fig. 18. *Arca ornata.*
Fig. 19. *Spirifer* sp.
Fig. 20. *Schizodus chemungensis.*
Fig. 21. *Hemipronites crenistria.*
Fig. 22. *Sanguinolites transversus.*
Fig. 23. *Palæoneilo attenuata.*
Fig. 24. *Sanguinolites unioniformis ?*
Fig. 25. ?
Fig. 26. ?
Fig. 27. *Edmondia burlingtonensis.*
Fig. 28. *Sanguinolites senilis.*
Fig. 29. *Bellerophon cyrtolites*, form with unusually irregular striae.
Fig. 30. *Bellerophon perelegans.*
Fig. 31. *Bellerophon cyrtolites*, cast.
Fig. 32. *Bellerophon galericulatus.*
Fig. 33-34. *Orthoceras indianense.*

PLATE X.

Fig. 1. *Schizodus newarkensis.*
Fig. 2. *Sanguinolites naiadiformis.*
Fig. 3. *Spiriferina depressa.*
Fig. 4. *Modiomorpha hyalea ?*
Fig. 5. *Allorisma nobilis.*
Fig. 6. *Proauctus semireticulatus.*

Fig. 7. *Crenipecten winchelli.*
Fig. 8. *Aviculopecten granvillensis.*
Fig. 9. *Rhynchonella contracta.*

PLATE XII.

Fig. 1. *Phillipsia præcursor.* Head and pigidium.
Fig. 2. Unidentified. Moot's run.
Fig. 3. *Edmondia ?* Perhaps *Grammysia* sp.
Fig. 4. *Sphenotus contractus.*
Fig. 5. Unidentified. Moot's run.
Fig. 6. *Productus shumardianus*, H.
Fig. 7. *Lyriopecten cancellatus.*
Figs. 8, 9, 42 *Pterinopecten carinifcrus.*
Fig. 10.. *Crania hamiltonæ ?*
Fig. 12. *Rhynchonella* sp. Moot's run.
Fig. 13–15. *Entolium shumardianum.*
Fig. 16–17. *Aviculopecten cooperi.*
Fig. 18. Unidentified. Moot's run.
Fig. 19. *Crenipecten (fœrstii ?)* Cuahoga shales.
Fig. 20. *Spirifer striatiformis.* Dorsal valve.
Fig. 21. *Crenipecten.* Upper division of Waverly.
Fig. 22. *Crenipecten granvillensis.* Dorsal valve.
Fig. 23. *Goniodon ohioensis.* Exterior.
Fig. 24. *Goniodon ohioensis.* Cast of both valves.
Fig. 25. *Goniodon ohioensis.* Lateral view of same.
Fig. 26. *Euomphalis latus.*
Fig. 27. *Allorisma convexa.*
Fig. 28. *Athyris* sp ?
Fig. 29. Unidentified. Moot's run.
Fig. 30. *Orthoceras* sp ?
Figs. 31, 32. Fish scales. Moot's run.
Fig. 33. Unidentified. Moot's run.
Fig. 34. Unidentified. Moot's run.
Fig. 35. *Sanguinolites*, resembling *marshallensis.* Moot's run.
Fig. 36. *Bellerophon* sp. Moot's run.
Fig. 37. *Naticopsis* sp. Moot's run.
Fig. 38. *Platyceras* sp. Moot's run.
Fig. 39. *Cyclonema strigillata.*
Fig. 40. *Stictopora striata.*
Fig. 41. Unidentified.
Fig. 42. (See Fig. 8.)
Fig. 43. *Productus shumardianus.*

ERRATA.

Page 12. Title. Instead of PART IV, read PARTS III and IV.

Page 24. 17 lines from bottom. Instead of C. TUMIDUS, read C. SUBCARDIFORMIS.

Page 27. 2 lines from bottom. Instead of RESPONSILITY, read RESPONSIBILITY.

Page 31. Under Prod. semireticulatus. Instead of VII, Fig. 11, read VI, Fig. 11.

Page 42. 15th line. Instead of SITUATION, read SINUATION.

Page 42, et seq. Instead of S. CENTRONATA, read S. CENTRONOTA.

Page 65. Instead of SCHIZODUS MEDINENSIS, read SCH. MEDINAENSIS.

Page 72. Instead of ALLORISMA COOPERII, read A. COOPERI.

Page 80. Instead of PALÆONEILO ELLIPTICUS, read P. ELLIPTICA.

Page 80. Instead of CARDINIA, read CARDINIA.

Page 84. Instead of GONOIDON read GONIODON.

Page 87. Instead of ENOMPHALUS, read EUOMPHALUS.

III.

CROSS-FERTILIZATION OF LOBELIA SYPHILITICA.

BY C. L. PAYNE.

The methods of bringing about cross-fertilization are very numerous. But it has been observed that the methods of fertilization conform to a few leading principles and types. And according to these principles the methods of cross fertilization may be divided into classes. The various modifications in the orders, genera, and species under these leading classes are only different applications of these principles and different methods of conforming to them. Thus we have the principle, that open flowers can be fertilized by the wind, and according to this principle we have a large number of plants, whose flowers are completely exposed to the wind. But in other respects the flowers may vary to suit the habits and circumstances of the several plants. Again, there is a principle, that melliferous plants attract insects and can make them the agents of cross-fertilization by adapting their contrivances for fertilization to them. These two principles are sometimes combined, and such plants have two chances for bringing about cross-fertilization. Here, also, there are many modifications. There are many other principles with contrivances adapted to them. A classification based upon these principles, it seems, would be as convenient as the general classification of plants. But of course it is hard to find a suitable principle of division. Hildebrand has made a very excel-

lent classification for phanerogamic flowers, according to the completeness with which they exclude self-fertilization. According to his classification the plant we have under consideration would come under class B. Male and female organs in one and the same flower (monoclinism), division 1. The organs of the two sexes not developed simultaneously (dichogamy), and subdivision (a.) The male before the female. And the division might have been carried farther, as there are several minor principles applied in different ways to the plants under the last division.

One of the most wonderful of the many contrivances for cross-fertilization is found in the lobelia family. The calyx is adherent to the two-celled ovary. The corolla is two-lipped; the lower lip is three-lobed; the upper lip is split and the division continued to the base of the corolla. Through this slit the united filaments and anthers bend out then in again over the lower lip. The anthers unite and form a conical-shaped figure. The upper portion projects beyond the lower (as in the case of a bird's beak) and forms the apex of the cone. A spur extends downward from this upper portion, forming a hollowed space. A clump of stiff hairs extends from the lower lip, and presses closely up to the tip of the apex, closing the hollowed space, except a small opening between the hairs and the spur in the back end. Now the pistil is sheathed by the stamens. It has a broad two-lobed stigma. Each lobe is protected by a sheath thickly covered with a ring of stiff hairs. At first the pistil is considerably below the lower extremity of the anthers. The pistil keeps growing up through the tube of the filaments, until it enters the chamber of the anthers at the proper time for fertilization. The inner walls of the pollen cells have by this time been absorbed, and the pollen has been let loose in the chamber. The pistil steadily presses the pollen toward the vertex. Escape backward is prevented by the broad stigma-lobes with their ring of hairs, thus some of the pollen is pressed into the little space at the vertex. When a bee alights on the lower lip and crawls down the tube, the slit in the back of which allows it to be expanded, the back of the bee bends down the stiff hairs. The pollen is hurled out upon it because of the tension. The pollen is carried to another flower and deposited on the stigma in the manner immediately to be explained. The pistil pushes on, driving out the pollen, and grows through the aperture in the vertex, protruding over the lower lip. Heretofore fertilization has been prevented by the sheaths. These are

now opened, and the stigma laid bare to catch the pollen from the bee's back, where it has been deposited by another flower, as previously described.

The general arrangement for cross-fertilization in the florets of the Compositæ is the same as that just described for the Lobeliaceæ. But the vast number, the wide distribution, and the varied habits of the genera and species under the Compositæ cause many special variations. These variations are shown especially by the arrangements of the hairs and the stigmatic papillæ. In some genera, just as in the Lobelia, these hairs sweep the pollen before them, forming a simple ring around the style at the base of the stigmas or aggregated in a tuft at the extremity of the stigmas. In other genera they spread over more or less of the surface of the style and the pollen is entangled among them. The mechanism for pushing out the pollen is farther perfected in some Compositæ by the contraction of the filaments of the stamens on being touched by the proboscis of the insect.

IV.

LIST OF DIATOMS FROM GRANVILLE, OHIO.

BY J. L. DEMING.

Diatoms are microscopic unicellular algæ. Though they were formerly regarded as belonging to the lower orders of the animal kingdom, microscopists are now agreed in placing them among the Plantæ. They are generally of a brown color, though frequently becoming greenish when dry. The endochrome, as the colored contents of the valves are called, is always symmetrically arranged. Each cell is composed of two similar and apparently parallel portions, the valves.

These valves, although nearly equal in length, are not of the same width; in fact they differ greatly. In consequence of the fine striations and other markings of the silicious valves, they constitute valuable tests of the value of microscopic objectives.

Diatoms may be often seen to move a little in the water or slime in which they exist. This is especially so in the case of the more elongated forms and for this reason they were regarded as having an animal nature; but it is now no longer believed to be so any more than in the case of the moving vegetable zoospores. There are many theories concerning the movements of Diatoms, but the most plausible one to me is, that heir motion is due to the process of imbibing and emitting fluids in process of their vegetable life.

Diatoms may exist as individuals, singly or in loose families; they are free or attached to other objects by little stipes, and are frequently imbedded in a mucous secretion. The free forms are locomotive and may be seen in constant motion under the microscope.

In the process of reproduction they bear a close resemblance to to the Desmids. They increase by division (whence the name from

Diatomos, a through-cutting), which takes place, not transversely, but longitudinally; and the lines which mark its progress are almost always visible in them. In this process of division new valves are formed along the line of division, the old ones remaining on the outer sides, and each new diatom cell having an old valve and a new one. But sexual reproduction takes place by conjugation and by the formation of auxospores, which restores periodically the normal size of the species.

Diatoms are quite abundant in the vicinity of Granville, Ohio, some of them being rare specimens. The following list I have identified for the most part, by recourse to the photographic plates from Aldolf Schmidt's "Atlas der Diatomaecen-Kunde."

Cymbellæ gastroides, K.
Navicula polystricta, Gru.
Navicula polystricta, (var.) *circumstricta*, Grunow.
Navicula senteltoides, Sm. Domb.
Navicula Cynthia, A. S. Java.
Navicula cuspidata.†
Navicula borealis.‡
Navicula cryptocephala.‡
Navicula entomon.‡ E.
Navicula biceps. E.
Navicula latissima, Greg.‡
Navicula consimilis, A. S.
Navicula lanceolata, K.
Navicula brevis, Greg.
Navicula latissima, (type), A. S.
Navicula longa, Greg.
Nitzschia coaretala.‡
Pleurosigma Spenceri, ‡.
Gomphonema acuminatum, E.
Fragilaria lanceolata. ‡.
Diatoma meridian-circulare.‡
Friceratium solenoceros, E.
Friceratium Jensenianum, Grunow.
Friceratium venosum, Brighton.

†. Not typical, but probably a variety.
‡. Identified by plates in Indiana Geol. Rep. Vol. II

Note.—Circumstances making it convenient to issue both parts at once, what follows may be regarded as Part II of Vol. III.

V.

NOTES ON PALEOZOIC FOSSILS.

BY AUG. F. FOERSTE.

CAMBRIAN.

MICRODISCUS PUNCTATUS, *Salter.*

(*Plate* XIII, *Fig.* 5.)

This species was described by Salter, (Quart. Journ. Geol. Soc., 1864,) from the Lingula-flags of Wales, at Porth-y-Rhaw. The head is semi-circular and the margins at the postero-lateral angles are slightly bent out again, forming almost a right angle with the posterior margin. The margin around the lateral and anterior portion of the head has an elevated border at the edge, which is cut transversely by numerous short grooves, giving it the appearance of a row of minute, closely set tubercles. The lateral lobes do not approach very closely to one another in front of the glabella, leaving quite a distinct vacant space. The glabella terminates posteriorly in a long spine. One of the accompanying figures, enlarged, represents the spines as equalling the length of the head; another, drawn natural size, could under no circumstances be considered longer than two-thirds of the head, and in fact is drawn only half as long. This would suggest that the spine of the enlarged figure is overdrawn, or that it was of an exceptional length. The middle lobe of the pygidium is said in the description to

have seven segments. But the drawing of an enlarged specimen represents seven segments very plainly, and suggests an eighth, and even a terminal indistinct tenth one by means of the shading.

In North America, in the St. John's Group at Ratcliff's Millstream, New Brunswick, is found a very similar form. There seems to be more variation in the form of the glabella, this often becoming more or less distinctly lobate on either side. The lateral lobes always approach to within a short distance of each other anteriorly, being separated by a deep groove rather than by a vacant space. The terminal spines of the glabella is also extremely variable, being quite short and rather blunt, or equalling two-thirds the length of the glabella, when it is very slender posteriorly. The edge of the margin often presents the milled appearance noted in the European form, this varying to a series of closely set tubercules. The middle lobe of the pygidium usually presents nine well marked segments and under favorable cir cumstances some of the finest specimens will show a tenth quite distinctly, and even faint indications of two more. Both head and pygidium are covered with minute granules.

Mr. Walcott, in his excellent monographs of our Cambrian fauna, referred the American specimens to the Welsh species, with a certain reservation on account of variations observed, and suggested the application of the name proposed by Mr. Hartt, *M.pulchellus*, in case they were found to be distinct. Our own investigations lessen, rather than increase the differences then observed..

CINCINNATI GROUP.

Lichas Halli, *sp. n.*

(*Plate* XIII, *Fig.* 4)

In 1842. Conrad described *Lichas Trentonensis* from the Lower Silurian rocks of New York. In the first volume of the palentological reports of that state, Hall re-described it and at the same time illustrated it in the accompanying plates. Among the illustrations on plate 64, figure 1e, is a specimen from the vicinity of Cincinnati, and manifestly distinct from the typical forms of *L. Trentonensis.*

For the sake of comparison we have outlined (Plate XIII, fig. 8,) the glabella and accompanying parts of *Lichas Trentonensis* as it occurs

at Trenton Falls, New York. The sides of the middle lobe of the glabella are but very slightly divergent posteriorly, reaching the occipital ring without any change of direction, therefore not forming a pestle shaped widening at the posterior end of this lobe. The lateral lobes also reach the occipital furrow, their sides preserving the same degree of curvature behind the palpebral lobes until they reach the occipital furrow. The facial sutures extend from the palpebral lobe with a short curve laterally and posteriorly to the posterior margin of the head. The fixed cheeks occupy *all* of that portion of the head which lies between the facial sutures, the palpebral lobes, and the lateral lobes of the glabella. Beginning near the posterior termination of the facial suture, a furrow, narrow but distinct, runs with a moderate curvature along the movable cheek forwards, within a moderate distance from the eye.

The Ohio specimens we propose to name *Lichas Halli* after the illustrious state geologist of New York. The sides of the middle lobe of the glabella at a short distance from the occipital furrow make a rapid double curve laterally, then incurve slightly until they reach the occipital furrow, giving by this means to the posterior end of the middle lobe of the glabella a shape somewhat like that of an apothecary's pestle, and which is characteristic of quite a distinct section of the genus *Lichas*. The sides of the lateral lobes of the glabella converge posteriorly and meet near the lateral edges of the pestle-like formation just described, but do not extend to the occipital furrow. Between the postero-lateral terminations of the lateral lobes, the lateral portions of the pestle-like termination of the middle lobes, the occipital furrow, and the fixed cheeks lie very marked lobes, which from their proximity to the occipital furrow may be called occipital lobes. In consequence of these lobes the inner posterior edge of the fixed cheeks is considerably incurved. The glabella as a whole is rather flattened above but anteriorly it curves rather rapidly down to the anterior margin of the head. The palpebral lobes are rather large. There seems to be no distinct furrow on the movable cheeks running from the anterior to the posterior sides of the same. The interpretation of the structure of the cheeks is not so clear from the specimens at hand but seem to follow some of the more familiar types. The posterior margin of the fixed cheeks namely curve forward, joins the posterior margin of the movable cheeks, the latter curving backward and forming with the anterior edge of the movable cheeks a broad pleura-

like wing to the head. The occipital furrow continues along the posterior margin of the fixed cheek as a deep furrow, but vanishes soon after the movable cheek. The pleuræ are about three-fourths as wide as the axial lobe. The entire surface is covered with low granules, none of which reach any great prominence. The specimen figured was collected from the upper portion of the Cincinnati Group in Clermont county, Ohio, by Mr. Clinton Cowen, who kindly presented it to me.

Lichas breviceps as identified from the Clinton Group of Ohio, shows similar structure of the glabella, but the occipital lobes are small and produce no marked effect upon the outline of the fixed cheeks. The palpebral lobes are also narrower. In the Waldron type we have failed to discern the occipital lobes and if present at all they must be very small. The palpebral lobes are however very prominent as in the Lower Silurian form. The movable cheek is very different as may be seen in an outline drawing introduced into the plate for the purpose of comparison.

UPPER SILURIAN—AMERICA.

Strombodes pygmæus, *Rominger.*

(*Plate* XIII, *Fig.* 18.)

In the Dayton limestone of Ohio, Mr. Van Cleve found a fossil which he labeled as *Sarcinula organum, Lamarck.* This is a form resembling Rominger's species above cited in apparently every particular except in the character of the elevations into which the pits of the calyces are sunk. These are somewhat more prominent than the figure accompanying the original description would lead one to suspect; but the difference is not so great that our specimens might not readily be a slight variation from the type. The interior of the pits is 2 mm. in diameter. The elevations are referred to series in one direction more readily than in any other, but still there is considerable variation in the distance between any two elevations. Six millimeters is the average distance, but this varies rapidly in different parts of the same specimen from 4 to 10 mm. The elevation of even the most prominent malliform cones does not exceed 2 mm. It is noticed that the

rugæ which striate the surface are more or less radial at the mouth of the pits but as they descend the elevation they rapidly take a common direction and become quite parallel and more or less wavy between the elevations. The direction of the striæ then is transverse to the direction in which the elevations are said to be more readily referable to series. This arrangement is very common in the genus *Smithia* of Edwards and Haine, a subgenus of *Phillipsastræa*, D'Orbigny.

The specimen referred to this species by Mr. William J. Davis, (Kentucky Fossil Corals, Pl. 123, Fig. 1,) has not the slightest resemblance either to the type or to the Onio specimen here under consideration; it belongs rather to that smaller variety of *S pentagonus* which is usually regarded as typical of the species. *S. incertus, Davis* of the same plate is a good medium sized specimen of the same species. *S. pentagonus*, Fig. 3, of Pl. 127, is a similar form with a slightly less distinct margin around the pits in the centre of the calyces. *S. striatus*, Fig. 1, of Pl. 122, represents one of the larger varieties. A form slightly less in size, with more defined margins about the pits, is figured by Rominger, Fossil Corals, Pl. 48, Fig. 1. His figure 2 of the same plate represents one of the smaller forms. The species is extremely variable both in the size of the calyces, and in the fineness of their radial striations. Variation is however the normal condition of species of wide geographical distribution.

Sphærexochus mirus, *Beyrich.*

(*Plate* XIII, *Fig.* 6.)

Since Hall, in the Geol. Rep. of Wisconsin. 1862, separated *Sph. Romingeri* from *Sph. mirus*, on account of distinctions presented by the pygidia at that time associated with undoubted glabellæ of a species of *Sphærexochus*, it has been the fashion of American paleontologists to refer all American specimens to Hall's species. To show that this is probably incorrect, a description of the glabella of a specimen obtained in the Guelph at Cedarville, Ohio, is appended, which will be seen to agree even in the minutest details with the European forms referred to Beyrich's species.

Glabella almost hemispherical, slightly broader than long; two small lobes cut off a part of each side of the glabella at the occipital

furrow, their diameter is about two-thirds of the distance which separates them, or but slightly less. The groove defining these lobes, the occipital furrow, the groove separating the fixed cheeks and then defining the anterior margin of the glabella are all very distinct. The facial sutures begin to define the fixed cheeks at a point near the upper margin of the lateral lobes of the glabella, then they pass within a moderate distance of the lateral lobes to a place slightly behind the middle of these lobes, after which they turn quite abruptly outward and then curve backward to the posterior margin of the head. At a point rather beyond the middle of the occipital border of the fixed cheeks, near the edge, there is a low tubercle. On each side of the glabella are two faint grooves which are readily overlooked, especially in casts. When examined however with a magnifier, and with the light thrown in the proper direction, they are really quite distinct. The first pair lie about two-thirds the diameter of the lateral lobes above their anterior margin; the second pair lie about the same distance beyond the second. Being short they are not readily seen in a view from above. The head parts of the Ohio specimens are therefore seen to agree perfectly with those of the European *Sph. mirus*. The pygidium associated with the Wisconsin species belongs to *Ceraurus Niagarensis*, as Hall himself afterwards noted. We fail therefore to discover what the distinguishing features of *Sph. Romingeri* are, but Ohio specimens at least belong to *Sph. mirus*.

UPPER SILURIAN.—AUSTRALIA.

Encrinurus Browningi, *sp. n.*

(*Plate* XIII, *Fig.* 7.)

The glabella is very much rounded and inflated for about two-thirds its length anteriorly, the posterior third is much narrower, about half the greatest width of the anterior parts, slightly widening behind, thus giving a marked concave outline to the sides of the glabella. The occipital furrow is itself not very deep, but the border behind it is elevated to such a degree as to give it some importance. Along the posterior half of the glabella the tubercles are arranged in quite distinct transverse rows. In the specimen figured, the first three rows have

four tubercles in each, the first from the occipital groove being quite small, increasing in size rapidly in the other two. The fourth row contains six tubercles of large size. After this the tubercles remain large but have no longer a regular arrangement transversely. The large size of the tubercles is very marked and characteristic. The eyes are about in line with the space between the second and third row tubercles. The groove separating the fixed cheeks is very deep. The fixed cheeks begin a slight distance behind the widest part of the glabella. The distance between the eyes is equal to the length of the glabella and occipital ring. Posterior to the eyes, the facial sutures make a sharp angle with the continuation of the occipital furrow. Immediately behind the eyes there are two rows of small tubercles which soon merge into one. Between the eyes and the glabella are the largest tubercles on the fixed cheeks, but even there are much smaller than those of the glabella. The continuation of the occipital furrow over the fixed cheeks is deep and narrow at first, rapidly widening and becoming shallower towards the postero-lateral margins of the head. The posterior border of the head is distinctly raised, defining the occipital furrow very well. If very carefully examined it shows low tubercles along its summit, but these might be readily overlooked.

Mr. S. G. DeKoninck, in Foss. Pal. Nouv. Salles du Sud., cites the occurrence of *E. punctatus*, *Brunnich* at Yass, 8 mi. southeast of Bowning, and also at Duntroon. But our specimen is evidently not of that species. The fact that the postero-lateral ends of the head in that species are sharp, acutely pointed would be sufficient to distinguish that species from ours. The shape of the glabella is also very different, as is well shown by a typical European specimen which has been introduced into our plate for the sake of comparison. Since the specimen from Duntroon however is said to be quite perfect we may also safely add that our specimen belongs to a different species from that of Duntroon as identified by DeKonnick.

Mr. R. Etheridge, Jr., has cited the same species, *E. punctatus*, from Bombala, but the material was not entirely satisfactory.

Mr. S. G. DeKoninck described *loc. cit*, a new species *E. Barrandei* from Yarralumla. He says however that the furrow separating the fixed cheeks from the glabella is feebly indicated, whereas in our specimens it is very marked. It resembles our specimen in the entire loss of the pointed ends of the movable cheeks which are so prominent in *E. punctatus*. Judging by the figure the tubercles are consid-

erably smaller on the glabella, and far more numerous ; there is a greater distance between the eyes and the continuation of the occipital furrow, and this is occupicd by a greater number of rows of tubercles, three. This is evidently the most closely related species, but if his drawing is at all correct then our species is quite distinct.

Encrinurus Mitchelli, *sp. n.*

(*Plate* XIII, *Figs.* 2, 3, 20.)

Glabella anterior to the facial suture not known in the larger specimen ; the facial suture gives the anterior outline of the remainder of the glabella an evenly rounded appearance. The sides of the glabella are moderately concave, widening anteriorly, having the greatest breadth at two-sevenths its length from the occipital furrow. On either side along the dorsal furrow are a row of large and very conspicuous tubercles or lobes which form a marked contrast with the rather small tubercles on the remainder of its surface. In the specimens before us there are five of these ; the first is compressed anteroposteriorly, the next three are well develeped, and the fifth is considerably smaller than these. The remainder of the glabella is rather thickly set with small tubercles. The fixed cheeks also have more conspicuous tubercles along the dorsal furrow, of about half the size of the corresponding tubercles on the glabella, and alternating with them, the eyes are about equally distant from the dorsal furrow and the continuation of the occipital furrow. Posterior to the eyes the facial sutures form a very sharp angle with the occipital furrow cutting the lateral margins of the head just at furrow ; at first two rows of small tubercles separate them, quickly merging into one. The tubercles increase in size toward the dorsal furrow. A moveable cheek belonging to the more broken specimen shows that the deep dorsal furrow after sharply defining the anterior part of the fixed cheeks, makes an equally prominent depression as it enters the moveable cheek, quickly decreasing in depth and broadening as it turns backward along the margin of the head. The part anterior to this groove according to the general morphology of the genus *Encrinurus* once must have formed the anterior part of the glabella. Like the adjacent parts of the glabella, it is covered with small tubercles. The

cheeks posterior to the grooves have but few tubercles and these are also small. The occipital furrow is well marked, and the occipital occipital margin is raised and distinct. The thorax is composed of twelve segments. The middle lobe is about three-fifths as wide as the lateral lobes. If characterized by well marked tubercles the specimens before us do not show them. The pygidium is triangular, broader than long, in the ratio of seven to five. The central lobe anteriorly is equal to about half the breadth of the lateral lobes. The lateral lobes with nine distinct anchylosed segments, with a possible tenth. These apparently without tubercles. The middle lobes with about twenty-eight transverse ridges. In casts these are broken or even indistinct along the middle of the lobes. Beginning with the fourth ridge every fourth succeeding ridge bears a tubercle at the middle. While studying the *Encrinuridæ* the question has often raised itself whether tubercles prominent in the cast might not be entirely absent on the surface of the pygidium itself but unfortunately we have never had the proper material to determine this question.

Two species closely related to *E. Mitchelli* have already been described from Australia by Mr. L. G. DeKoninck. The first is *Cromus Bohemicus*, *Barrande*. A comparison with the Bohemian species however shows marked differences. The large tubercles at the dorsal suture are in the Bohemian species represented as lobes with the smaller tubercles of the remainder of the glabella also present on them. The eyes are farther removed from the occipital furrow. There are twelve well marked ridges on the lateral lobes of the pygidium, the summit of which is represented as being flat while in ours they are distinctly rounded. The sides of the pygidium are also represented as being denticulated; in our specimens traces of a similar structure are visible but they are not sufficiently distinct for delineation. The description of the specimens from Yarralumla makes it probable that these are also distinct although closely related.

The pygidium of the second species described, *Cromus Murchisoni*, *L. G. De Koninck* is said in the text not to have been found. The pygidium figured in the plate and mentioned in the explanation of the same, undoubtedly was associated by him with his *Encrinurus Barrandei* of the same plate, and agrees well with his description of that species. *Cromus Murchisoni* is readily distinguished from our species by the absence of the large tubercles along the dorsal furrow, the arrangement of the posterior tubercles in transverse rows (a fact not

observed in ours; indeed it suggests in this our first species, but the anterior of the glabella is not round; the drawing evidently leaves much to be desired), and the greater distance of the eye from both dorsal and occipital furrows.

Phacops serratus, *sp. n.*

(*Plate* XIII, *Fig.* 1.)

Head with semi-circular outline, almost twice as broad as long. Anterior lobes of the glabella equalling eight-elevenths of the length of the head; its anterior margin, instead of being regularly rounded as is usual in most species of *Phacops*, is rounded most at the middle of its outline and at its junction with the dorsal furrow, giving the intermediate outline on each side a somewhat compressed appearance. The curvature of the sides of the glabella is small, they converge posteriorly and form an angle of about seventy five degrees with each other. With the exception of a faint median elevation the surface is quite flat, above bending rather abruptly into the dorsal furrows and at the anterior margin even becoming incurved. The specimen is slightly exfoliated so that it is impossible to say if there were any grooves on its surface, but if so they must have been rather inconspicuous. It is covered however with low small tubercles. This lobe of the glabella is defined posteriorly by a furrow which is quite marked at the sides, but toward the middle it becomes very shallow forming a sort of axis, and curving more or less forwards. This furrow cuts off from the remainder of the glabella two small posterior lobes, at either side considerably depressed below the general level of the glabella and terminated with a small knob, posteriorly it is defined by the well marked occipital furrow. The occipital ring is very broadly subtriangular and is terminated with a distinct, short, pointed projection, which repeats itself on all the segments of the axial lobes of the thorax, gradually becoming indistinct, and vanishing soon after reaching the first ring of the axial lobe ot the pygidium. The eye has a reniform outline and extends from a short distance behind the point of greatest width of the glabella to within a short distance of the continuation of the occipital furrow. The palpebral lobe is strongly defined by a very distinct furrow which also outlines the posterior parts of the eye.

There are sixteen vertical rows of lenses in the eyes and the largest row seems to have contained nine lenses, but this can not be determined since the eye seems to be a little injured below. That part of the fixed cheek which lies between the eyes and the dorsal furrow seems strongly arched, behind the eye this cheek is very narrow and then it widens but moderately before meeting the occipital furrow, which curves forward along the side of the head and here, meeting the furrow defining the posterior part of the eye, bends forward giving great relief to the eye, and running in a much less distinct form along the base of the incurved front of the glabella. The occipital furrow is everywhere very distinct. The postero-lateral outlines of the head are rounded. The thorax consists of eleven segments, The middle lobe is almost as broad as the lateral lobes, on account of the quite sudden lateral deflection of the pleuræ at about half their length. The sides of the segments of the middle lobe are more or luss curved forward, and are slightly thickened. The length of the pygidium is equal to about two-thirds its width. The middle lobe of the pygidium at its anterior portion is about two-sevenths as broad as the pygidium; it tapers quite rapidly posteriorly. It is marked by seven transverse rings of which the sixth is very low and the seventh is very indistinct. The pointed tips already mentioned are readily noticeable only on the first ring, on the second they are represented by a low granule, on the third this becomes indistinct, on the fourth they disappear. The lateral lobes are marked by six ridges of which the sixth is indistinct. The first ridge is quite broad and is marked by a well defined although shallow furrow. On the second ridge this furrow becomes narrower, on the third it is no longer noticed. The furrows defining the middle lobe are distinct and give it a high relief.

In Prodr. Pal. Victoria, Dec. III. 1876, Prof. McCoy described from the Upper Silurian beds at Yering *Ph. fecundus*, *Barrande*. Since this is the species most closely related to ours we compared our specimens with the Bohemian species with the following results. In the Bohemian species the compression on each side along the anterior of the glabella is not noticed. this part of the glabella being evenly rounded. The anterior lobe of the glabella is characterized by distinct narrow lunate furrows, of the arrangement typical with this genus. The middle lobe of the pygidium is less tapering posteriorly, and contains eight well characterized transverse rings in addition to a small terminal piece. The ridges or anchylosed segments of the lateral lobes

are all distinctly grooved along their summit. The feature upon which we place the most stress however is the line of pointed elevations along the median line of the animal, beginning with a very conspicuous termination of the occipital ring and ending with a few low granules on the pygidium. These give the axial lobe when viewed from the side quite a serrated appearance. If these be not of specific value, the species fails and becomes mere variety.

Cyathophyllum australe, *sp. n.*

(*Plate* XIII, *Figs.* 12, 13, 14.)

Externally the polyp is marked by quite distinct costæ. The polyp is conical, slightly curved, the side towards the apertural gap being the more convex one. Fine striæ or lines of growth, with wrinkles of no prominence, pass around the polyp. Lamellæ in the calyx, 40, low and rounded, nearly rounded above, half of them disappearing soon after reaching the bottom of the calyx. Between the lammellæ in the groove is a series of minute points, about 11 of which occurs in a length of two mm. Length of polyp, 16 mm; breadth, 10 mm, depth of calyx at least 5 mm, it may have been a little greater. Found in the hardened grey-brown shales east of Bowning Hill, Bowning Parish, New South Wales, Australia. Presented by Mr John Mitchell.

In Pal. Foss. of Cornw. Dev. and W. Som. Mr. John Philips figures under the name of *Turbinolopsis bina*, *Lonsdale* a species presenting many of the characteristics of the Australian species. A row of small pits is found in the bottom of the grooves, but they are less numerous. The line of elevation between the pits is also noted in the Australian form, but the denticulations of the lammellæ noted in the English species are absent or at least not noticeable in our specimens. A form similar to the last is described by Mr. Rudolph Ludwig in Coroll. aus Pal. Form. under the name *Zaphrentis caudata*. The number of pits in the groove between the lamellæ is larger than in the English species; the denticulations of the lamellæ are smaller in number than the pits between them agreeing in this with the English species. The calyx is deep, at the centre it seems from the casts to be still further depressed, and on the side there seems to have been a distinct septal fovea. These species all agree in having a deep calyx,

the lamellæ along the calyx are low, not reaching into the calyx, and instead of small transverse leaflets between the disseppiments as in *Cyathophyllum*, there are only minute pits. They however belong to that class of fossils typified by *Cyathophyllum* and form a connecting link with *Zaphrentis*. The pits may be said to represent the spaces between the disseppiments in *Cyathophyllum*, and the denticulations in the last two species, the coarser denticulations of the sub-genus *Heliophyllum*. We think it convenient to establish another subgenus for these aberrant forms and as such suggest *Palæocyathus*.

CYATHOPHYLLUM PATULA, *sp. n.*

(*Plate* XIII, *Figs.* 9, 10, 11.)

Polyp very much much broader than long. One at hand is 10 mm. high, 35 mm. broad in one direction, and 29 mm. broad in a direction at right angles with the last. Another specimen was 8 mm. high, 42 mm. broad in one direction, and about 34 mm. at right angles with this. A third specimen was about 9 mm. high and 22 mm. broad. So that the variation is evidently a matter of breadth more than that of length. The shape of the polyps would indicate as much. For a distance of about 8 mm. from the centre the base of the polyp shows its greater convexity, or rather, increase in hight, and this is also the thickest part of the polyp itself. Beyond this radius it rapidly grows thinner, its thickness usually being 2 mm. or less, so that in a large sized polyp there may be a thickened centre of about 16 mm. diameter and a very fragile border of 12 mm. or more entirely around the margin. This *border* is always flattened on the side of the central gap. The entire coral is always curved very decidedly upwards on the side of the apertural gap. Sometimes this curvature is even and rounded, often it is more or less irregular and broken by striæ of growth. This difference in growth between the side at the central gap and that at the apertural gap places the centre of the coral always considerably closer to the apertural gap. In the first specimen above noted the centre of the coral is 11 mm. from the apertural gap and 16 mm. from the central gap. It may be noted that in all corals of this group I have examined the side of greatest curvature was always on that of the apertural gap, and that if

anywhere a concave curvature took place it appeared strongest nearest the base of the coral on the side of the central gap. Exteriorly the coral is marked by the radiating costæ, by lines of growth, which usually are not very prominent nor closely set, and by much finer concentric striæ, best seen by aid of the magnifier. Interiorly the polyp is seen to be composed of a large number of lamellæ, among which there is very little increase by intercalation, this usually taking place through successive implantations at the various gaps. As might be judged from the thinness of the coral, the lamellæ are not very much raised above the epithecal covering. Excepting near the center they are little more than low ridges. At the center they seem to be slighlly twisted together and to be slightly depressed, forming a narrow shallow cup; our specimens do not show this part well. The number of the lamellæ of course varies with the breadth of the specimen. In the first specimen mentioned there were about 130; the average is 12 or 13 along the margin in a distance of 10 mm. A cross section near the center of the coral shows that at this point the lamellæ are thin and are crossed by vesicular tissue. The lamellæ along the sides are much indented in a manner similar to that characteristic of the subdivision of this genus known as *Heliophyllum*. I however know of no form of this genus which has any resemblance to this species. Like the species last described it forms an interesting aberrant varation of the genus.

It will be noticed that *S. G. De Koninck* quoted *Ptycophyllum patellatum*, *Schlosheim* from Dangelong. This is a species very similar in form, may however be ever be superficially distinguished by the fact that it has conspicuous elevations of long and short lamellæ, and that these begin to be twisted already at a short distance from the centre.

CYATHOPHYLLUM BOLONIENSE, *Blainville*?

(*Plate* XIII, *Fig.* 15.)

Corallum composed of numerous polygonal polyps. Polyps typically five or six sided, but often with four, seven, or eight sides

on account of the unequal compression of the polyps. Their walls are not perforated, those of adjacent polyps are not intimately connected so that in case of fracture, the coral often splits along the middle of these walls Weathering will often loosen the polyps in a similar way. The broken coral then assumes a columnar appearance. The columns are longitudinally corrugated at regular intervals by continuous ridges, five or six on each side of its polygonal outline; and also transversely corrugated. but at very irregular intervals. There are also numerous transverse striæ, which appear under a lens. Interiorly it consists of about thirty-five lamellæ which extend from the walls towards the centre. The greater part disappear before reaching a distance within one milllimetre of the centre, and of the rest occasionally one or two reach the very centre; in that case some of them sometimes seems to pass on for a slight distance beyond the center. The spaces between these lamellæ are occupied by vesiculose leaflets or dissepiments.

We do not believe that this species is really identical with the French species, but the structural similarity is greater with this species than with any other known to us. The Australian form however has a smaller number of lamellæ, in a cross section they are seen to be often more or less wavy, and not uniformly straight as our figure would indicate, the number of disseppiments is also slightly less numerous than there represented. The general effect is however well given. These minute differences were noticed after the drawings were made. It differs from *C. hexagonum*, *Goldfuss* in the absence of a zone of thickening in the lamellæ about the centre of the polyp. From *C. rugosum*, *Edw. and Haine* it differs according to Rominger's identifications, in the much smaller number of dissepiments, and in the fact that the lamellæ do not lose their character at a certain distance from the centre and then continue are mere ridges over the tabulæ. The interior termination of the lamellæ is far more regular.

While our specimens show a close structural affinity with *C. Boloniense*, the fact that we have not well preserved views of the calyces prevents our determining whether the slight variations observed are specific or varietal in nature.

ENDOPHYLLUM ———.

(*Plate* XIII, *Figs.* 16, 17.)

Corallum composed of numerous polyps, polygonal or hexagonal

in outline and separated by thin walls. These walls are most readily detected in weathered specimens, on account of yielding most readily to the dissolving action of the atmosphere. In cross sections they are seen as thin wavy outlines separating the vesiculose tissue of adjacent polyps. On account of the confused structure of this tissue these walls are then seen only on careful examination, but then they are marked enough. The interior of the polyp is filled with vesiculose tissue about the walls without traces of lamellæ, next comes a zone in which the vesiculose tissue is combined with radiating lamellæ, the vesicular tissue itself becomes more regular in arrangement and tends to combine in more or less circular rings around the more central portions of the polyp. Near the centre these rings usually become suddenly indistinct or entirely vanish. In this case they represent the more typical characters of the genus. In adjacent polyps the variation may be more gradual and then one of the more conspicuons characters of the genus fails. In one of the numerous polyps with this compound structure which may be taken as typical, the diameter of the entire polyp is 9 mm; the diameter as far as the exterior limit of the area of mixed lamellæ and vesiculose tissue is 5 mm. The diameter of the last easily seen ring at the interior limit of the vesicular tissue is 2.5 mm. Longitudinal sections show the vertical lamellæ towards the centre and the vesicular tissue quite strongly ascending forming on the average an angle of about thirty degrees with the centre of the polyp although this of course is very variable.

Spongophyllum Sedgwicki, Edwards and Haine in British Fossil Corals, plate 56, figure 2d, is a similar form but smaller. The Australian species is new. A description of the calyces is still necessary before science can be burdened with another name. When that is accomplished *spongohylloides* might not be an inappropriate term.

Pleurodictyum problematicum, *Goldfuss?*

(*Plate* XIII, *Fig.* 22.)

Fossils found in the form of casts. Corallum compound, composed of polyps intimately united by their walls. The walls are perforated, the perforations connect the cells of adjacent polyps. The base of the corallum is flat; there being no polyps here to connect the

base of the corallum is flat; there being no polyps here to connect the casts show no traces of connecting perforations. This base of the corallum we know from analogy to have been covered by an epithecal membrane, but that part of the cast has not been seen. The upper surface of the corallum was broadly convex. The separate polyps were internally grooved longitudinally. The grooves are shallow, and rounded, and vary in number. There are usually from 25 to 30 of them in each polyp cell, and 10 to 12 of these are usually found on that side of the polyp which lies against the epithecal membrane in basal polyps. Between these grooves are raised areas or ridges, also rounded, bearing numerous low, round, pointed tubercles. They are so small that they do not merit the name of spines. These spines may occur as a single irregular series, or in two or three irregular series. Sometimes they are very irregular in arrangement, at other times the arrangement in series is very readily noticeable. All these variations take place in the same corallum. The earlier formed basal cells are usually pressed more or less out of shape below on one side, so as to form a pseudo-base. Those later formed have quite regular polygonal outlines, excepting that the side adjacent to the epithecal membrane is always larger than the rest. Diameter of base of corallum 29 mm. A much smaller specimen, 12 mm. broad presents every feature of the former excepting that there is a polyp cell in the centre flattened around the very base so that the pseudo-base is radiably striated, and the longitudinal ridges along the cell walls are more prominent. It seems however to be merely a young specimen.

In 1829, Goldfuss in Petref. Germ. published a fossil under the the name of *pleurodictyum problematicum*. This is entirely similar to the Australian species generically, differing however strongly in the possession of a tubular coiled body which is more or less interwoven with the base of the coralites. This body is found to be frequently not present and hence is regarded as only a parasitit organism and hence not a proper character of the genus.

In 1842, De Koninck established the genus *Michelina*.

In 1851, Edwards and Haime in Polyp. Pal. associated under *Pleurodictyum problematicum Goldfuss* three distinct types. The first is that described by Goldfuss. The second consists of a colony of polyps without vertical ridges or series of tubercles. The third has vertical ridges but no tubercles. A fourth specimen had vertical

ridges strongly marked; we do not however know whether it belongs to the first or third types.

In 1866 Mr. Rudolph Ludwig in Cor. aus Pal. Form. divided *Pleurodictyum* into two genera, giving each a new name, thus practically abolishing this genus. *Ptchychochartocyclus* contains those forms in which the interior walls of the polyp have longitudinal ridges, and these ridges are beset with distinct tubercles. *Taeniochartocyclus* contains those forms in which the ridges are not beset with tubercles but are smooth. They correspond to the first and third types of Edwards and Haime.

In Kentucky Fossil Corals, Mr. William J. Davis figures a new genus, *Procteria*. The figures seem to indicate the existence of mural pores connecting the polyps and also of tubercles ornamenting its interior. An examination of numerous specimens show that the character of the ridges is extremely variable in both tuberculated and non-tuberculated forms, and that they are often absent. At any rate we do not find in the figure of *Procteria* any thing to distinguish it from *Ptchychochartocyclus*, and this is only a synonym of *Pleurodictyum* even if it be indeed considered necessary to subdivide the genus. It will be therefore a matter of interest to learn what the forthcoming text may have to offer on that subject.

Forms have been referred to *Pleurodictyum problematicum* from various localities in North America and with a range from the Onondaga Group of New York to that of the Waverly Group in Ohio. We believe that on study these would be found to belong to several distinct species. Notwithstanding this range, the large celled forms of corals which pass under the name of *Pleurodictyum* are usually typical of Devonian strata, and are found there most frequently.

Pleurodictyum has been identified by Rominger and Lindstroem with *Favosites* and *Michelinia*. The type of the genus is more of the character of *Michelinia*. It seems to us therefore that *Pleurodictyum* has precedence over *Michelinia*. It contains typically the species of Goldfuss, the first type of Edwards and Haime, *Ptchychochartocyclus stigmosus*, *Ludwig*, and apparently the *Procteria* of Davis. If it be considered admissable to separate the forms without the tubercles, Ludwig's genus *Taeniochartocyclus* has the precedence.

We prefer also to retain the name *Pleurodictyum* for the Australian form in particular, because the vesiculose tissue of *Michelinia* has not as yet been seen in Australian specimens. For a discussion of the

genus *Pleurodictyum* Nicholson's work, Pal. Tabulate Corals should be examined. The Australian fossils here described are part of a series kindly forwarded to us by Mr. John Mitchell of Bowning. They have all been obtained in the district near Bowning, New South Wales, Australia. The fossiliferous rocks here are all referred to the Upper Silurian Group. They form a great synclinal basin from east to west. Near the base of the exposed series is a bed of hardened greyish-grown shale about 50 feet thick. This has furnished the tribolites the first two species of *Cyathophyllum* and the *Pleurodictyum*. Beneath this bed of shale is a layer of limestone containing many corals. From this we obtained *Cyathophyllum Boloniense* and the *Endophyllum*. The tribolites are all characteristic Silurian types. The corals have their nearest analogues in the Devonian formations. We find associated with the tribolites also two species of *Pinnatapora* or *Glanconome*, *Goldfuss*. Species of this genus usually occur in carboniferous and sub-carboniferous strata, and are not known to descend below the Devonian series elsewhere. It is evident from these remarks that a careful study of the fossils of this district would be an unusually valuable contribution to the study of paleontology.

CARBONIFEROUS.

Chainodictyum laxum, *Foerste.*

Siuce the first publication of this species we have obtained good casts of the porifous face. This shows that the cell orifices are elongated and are arranged in oblique rows across the branches; their partition walls appear at the surface as more or less wavy, usually in osculating striæ. Two or three cells occupy the width of a branch.

McCoy in Carb. Foss. Ireland, published *Retepora undata* with the following description: "Irregularly cup-shaped, interstices anastomosing, flattened; fenestrule ovate, pointed at one end; poriferous face with five or six rows of pores in quincunx; reverse with waved or scale like, semicircular ridges. This species we have seen from Kildare and identify with our genus. The lunate cross-striations on the reverse side are also conspicuous. The cell apertures are similarly elongated and bordered by raised ridges. Compared with our species however the branches are much coarser and broader; being

usually a millimetre (or slightly more) wide, whereas the branches of the American species have a width of .3 to .38 mm.

Lophophyllum profunda. *Edwards and Haime.*

(————————)

In 1851, Edwards and Haime published in Polyp. Terr. Pal., under the name of *Cyathaxonia profunda* * a description of a coral collected at Flint Ridge, Ohio, which curiously enough was overlooked in preparing the catalogue of Flint Ringe fossils for the second volume of this bulletin.

Curiously enough both Edwards and Haime, and McChesney refer their species to *Cyathaxonia*, after *Lophophyllum* had been already established. To us indeed the two genera seem to be very distinct, but there is no doubt that the species here under consideration is far more closely allied to *Lophophyllum Koninckí* than to *Cyathaxonia cornu*, the types of the two genera. In deference to the opinion of those who have made a special study of these genera we leave them separate, and refer our species to *Lophophyllum* as is the American custom at present. We believe however the *L. proliferum* is only one of the many varations of *L. profunda*, and should give place to the latter name.

* "We know this species only by the interior cast of its calyx. The cast shows that the calyx was subcircular and deep; as it is more developed on the side of the septal fossette we think that the polyp was curved. The columnella is long and its transverse section subelliptical, 24 principal lamellæ quite large, well developed, alternate with an equal number of much smaller ones and arrange themselves about the columnella in a somewhat branched manner. Diameter of the calyx, 18 mm; its depth, 15."

This is really a very good characterization of Ohio specimens in the form in which they are usually found. But after considerable pains we found a few specimens which preserved the fossil itself These in the last bulletin we identified with Cyathaxonia prolifera of McChesney. On Plate XII we figured the fossil itself, and on Plate II may be found an illustration of the cast.

PLATE XIII.

Fig. 1. *Phacops serratus, n, sp:* the head accidentally removed a li tle from the thorax in the rock.
Fig. 2. *Encrinurus Mitchelli, n. sp.* part of the head missing
Fig. 3. *Encrinurus Mitchelli, n. sp:* a fragment, showing the large tubercles at the dorsal furrow of the head; a typical specimen.
Fig. 4. *Lichas Halli, n sp.*
Fig. 5. *Microdiscus punctatus Salter;* head, Museum Com. Zoology, Harvard Univ.
Fig. 6. *Sphærexochus mirus, Beyrich;* a glabella and fixed cheek.
Fig. 7. *Encrinurus Bowningi, n. sp.* glabella and fixed cheeks.
Fig. 8, *Lichas Trentonensis, Conrad;* head, outline, Mus. Comp. Zool.
Fig. 9. *Cyathophyllum patula, n. sp;* a cross-section of unusually wrinkled form.
Fig. 10. *Cyathophyllum patula, n. sp;* the lower side of two polyps.
Fig. 11. *Cyathophyllum patula, n. sp.*; a few lamellæ enlarged.
Fig. 12. *Cyathophyllum australe n. sp.* the exterior of the calyces seen from a cast, partly restored.
Fig. 13. *Cyathophyllum australe n. sp*; a cast.
Fig. 14. *Cyathophyllum australe n. sp*; a few lamellæ and grooves enlarged
Fig. 15. *Cyathophyllum Boloninense, Blainville;* a cross-section.
Fig. 16. *Endophyllum (sphongophylloides?)* a cross-section.
Fig. 17. *Endophyllum;* the same, a vertical section.
Fig. 18. *Stromboides pygmæus, Rominger;* part of a corallum collected by Mr. John Van Cleve.
Fig. 19. *Encrinurus punctatus, Brunswick;* a European specimen, figure taken from the work Fr. Schmidt, on East Baltic Silurian Trilobites.
Fig. 20. *Encrinurus Mitchelli, n. sp;* a moveable cheek.
Fig. 21. *Lichas breviceps, Hall, Waldron.* Indiana, Mus. Comp. Zool.
Fig. 22. *Pleurodictyum problematicum, Goldfuss?* View of base of casts, the epitheca being gone.

ERRATA.

Page 122, instead of *Encrinurus Browningi* read *E. Bowningi.*
Page 132, instead of *Spongopylloids* read *Spongophylloides.*

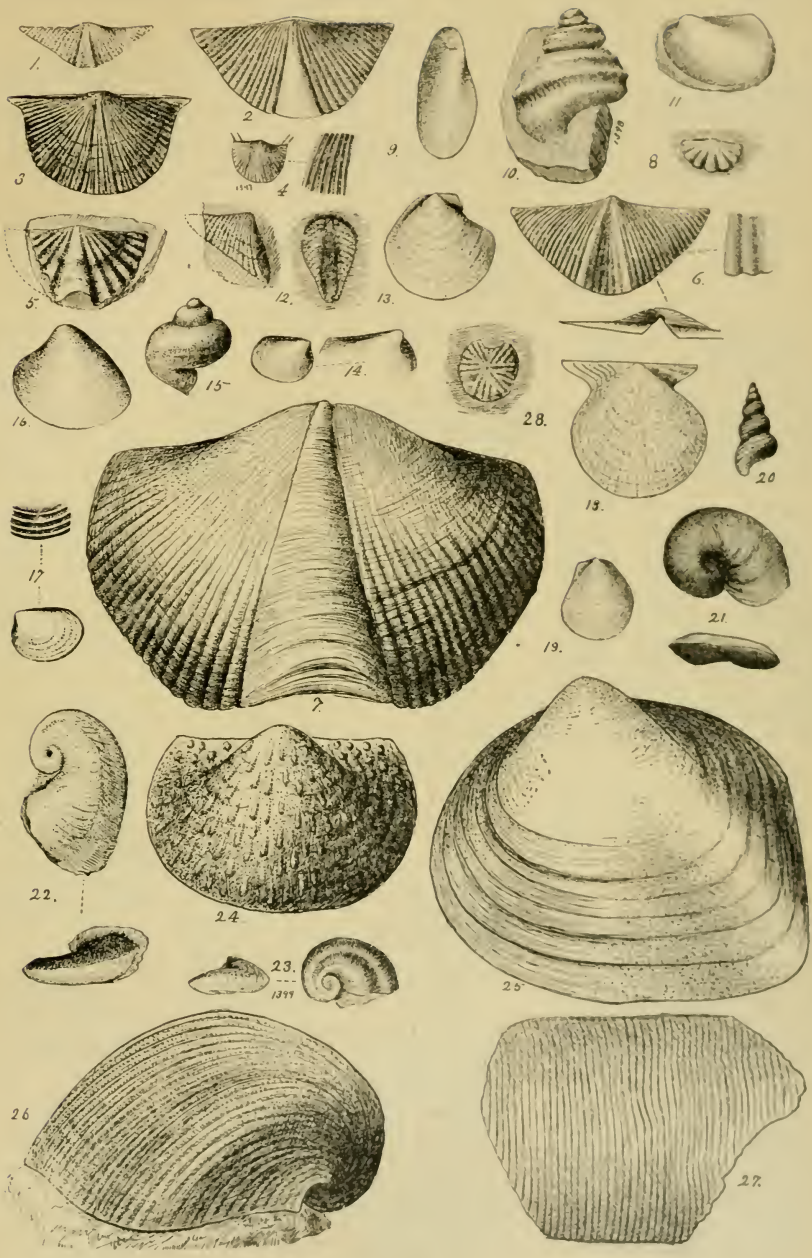
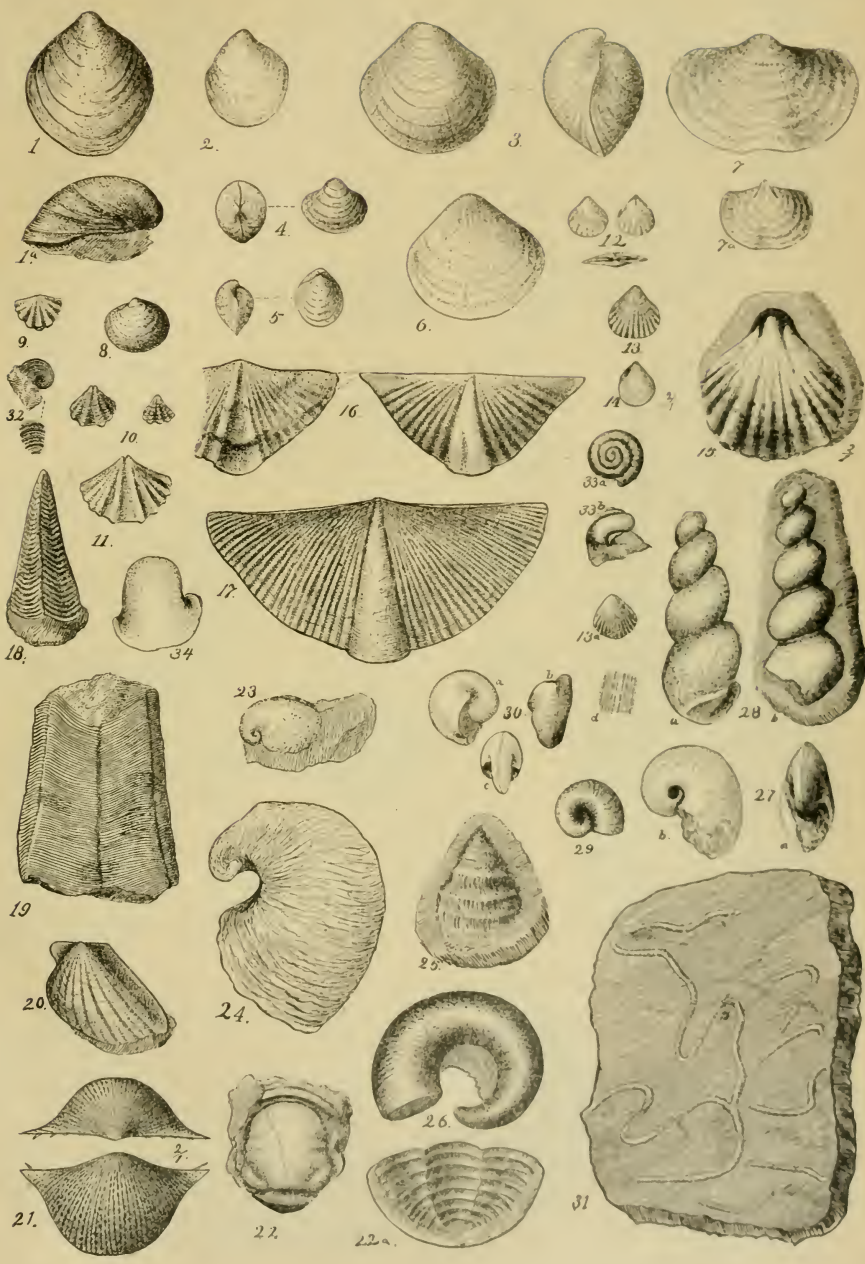


PLATE I.



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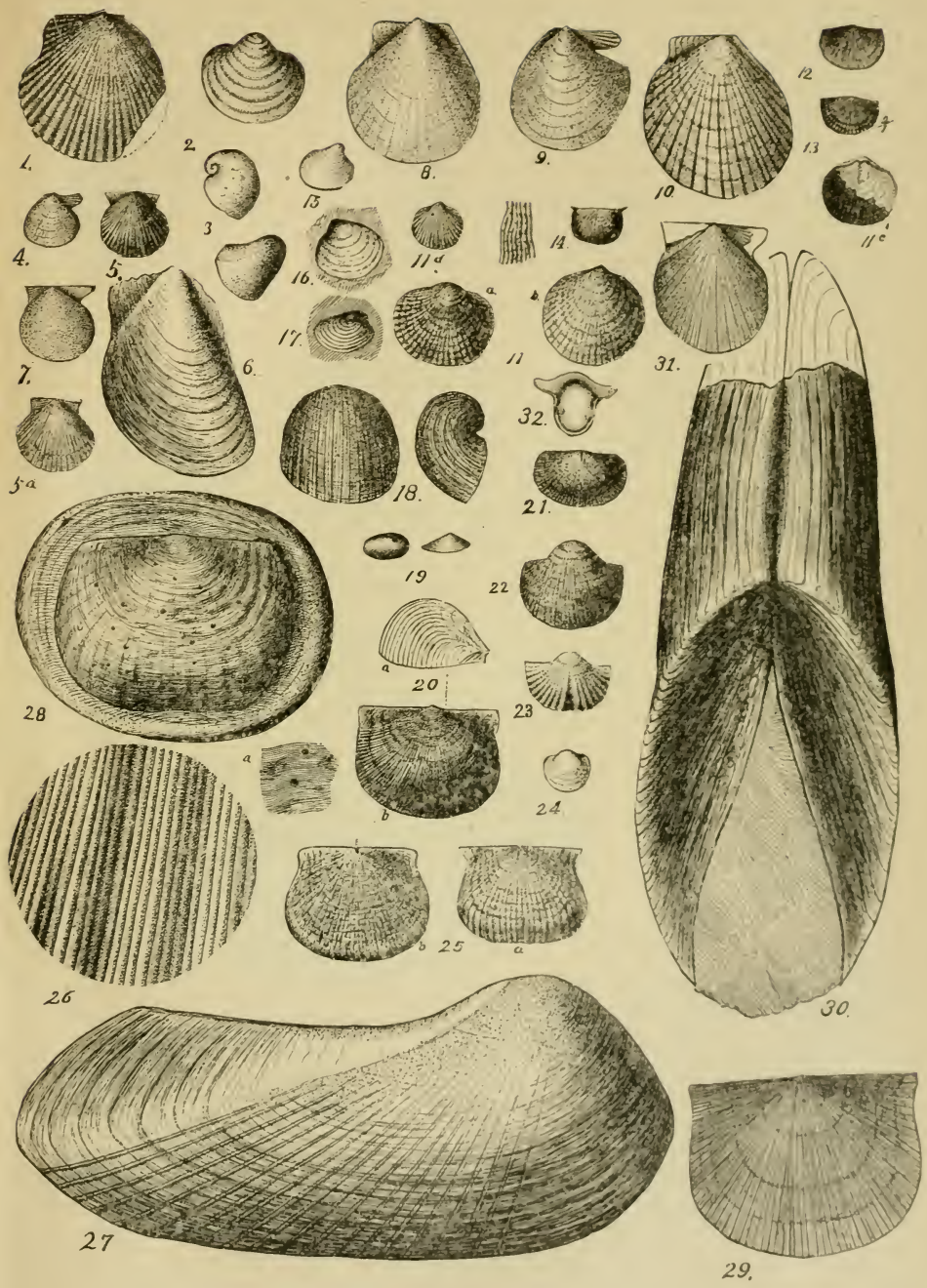
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PLATE III.

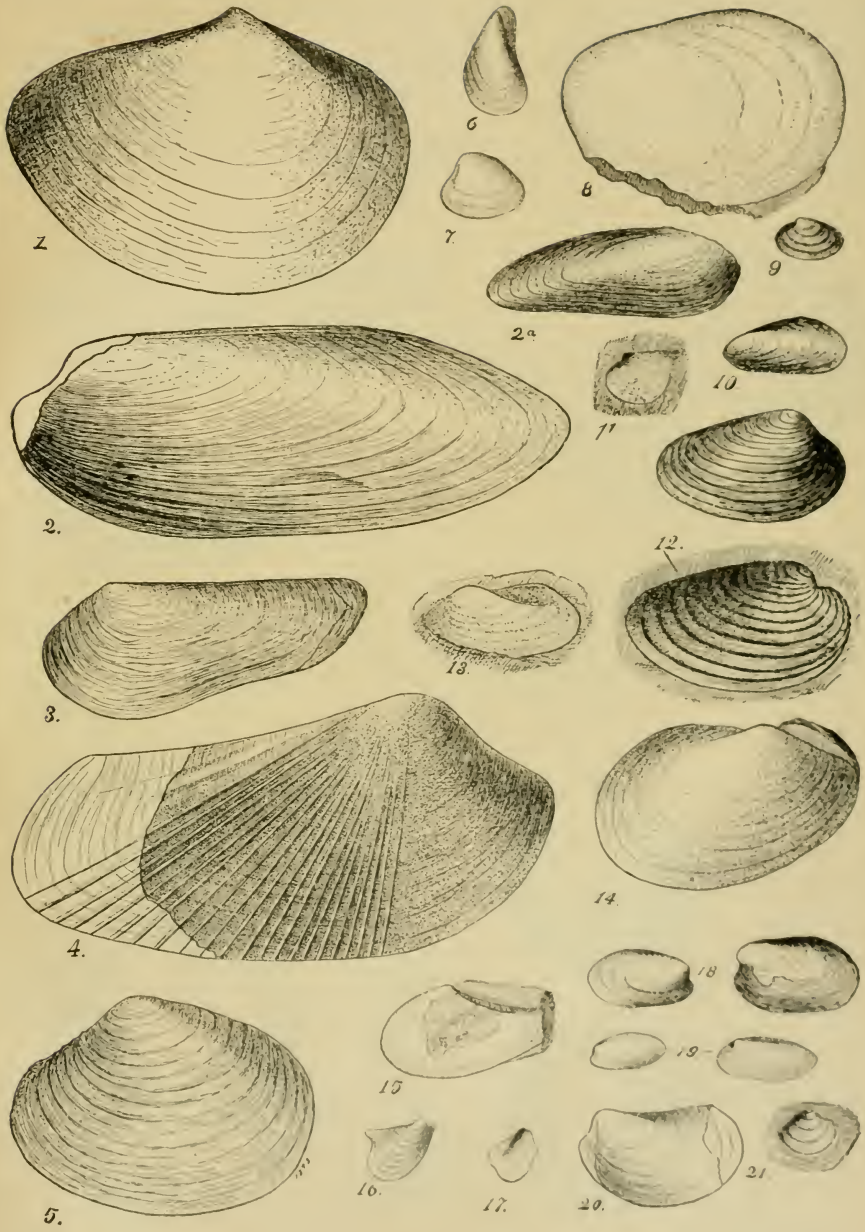

PLATE IV.

Fig. 1.

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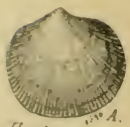


Fig. 9.

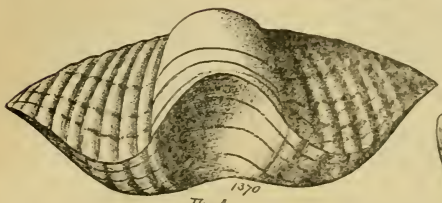


Fig. 4.

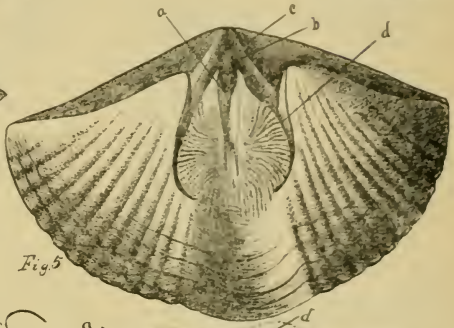
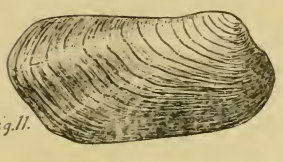


Fig. 5.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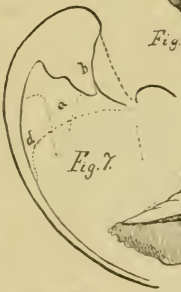

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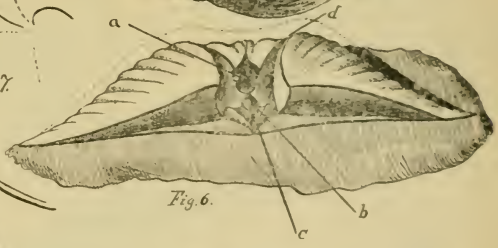

Fig. 6.

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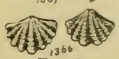
Fig. 13.

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Fig. 14.

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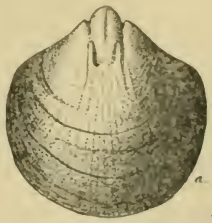

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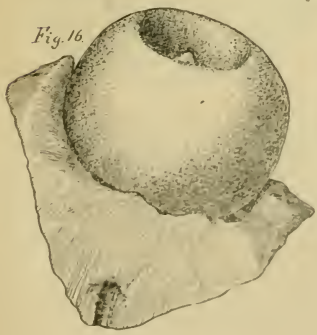
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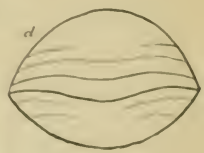
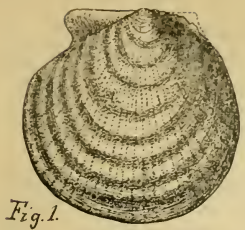


Fig. 18.

PLATE V.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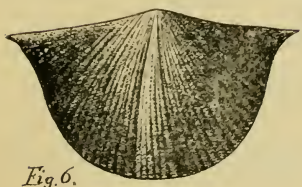
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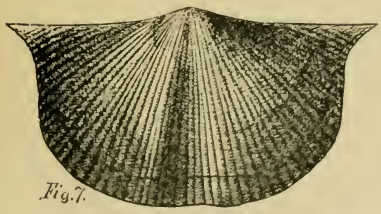
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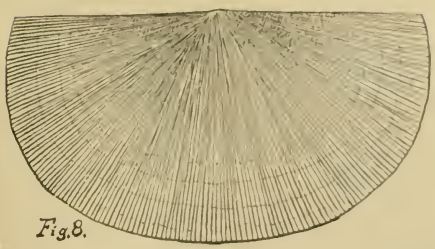
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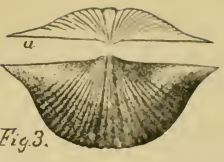
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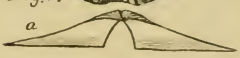
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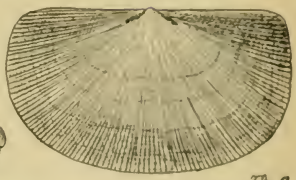
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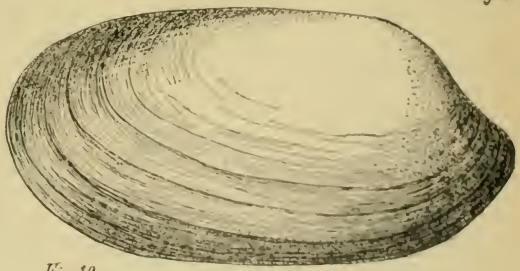
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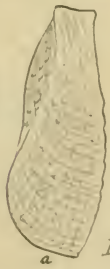
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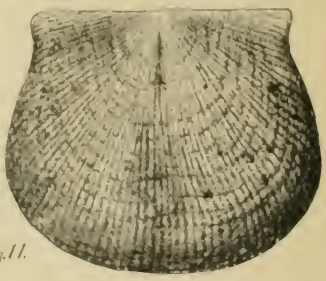
Fig. 11.

PLATE VI.

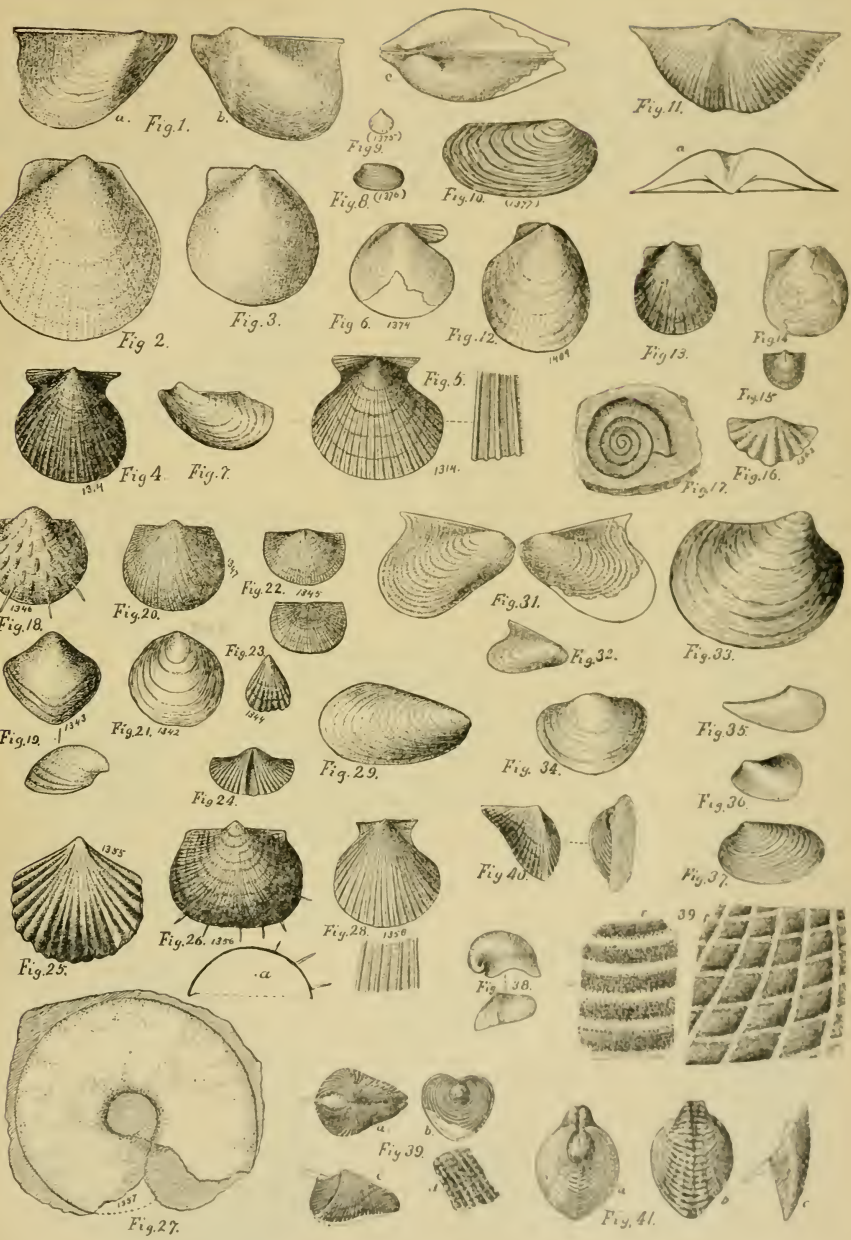
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PLATE VII.

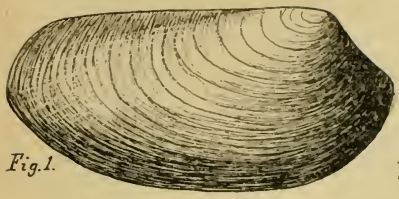
Fig.1.

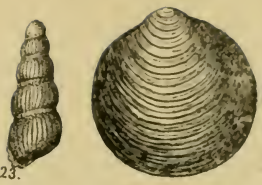
Fig.13

Fig.14

Fig.23.

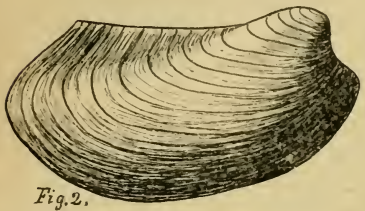
Fig.2.

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Fig 2

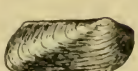
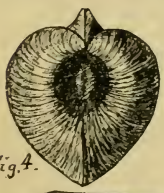


Fig 10.

Fig 22.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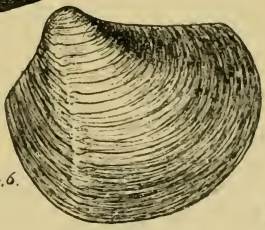
Fig.6.

Fig.11.

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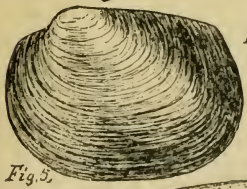
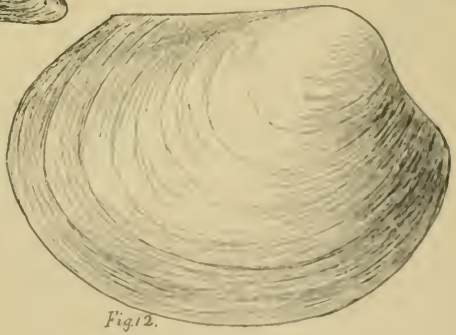


Fig.5.

Fig.7.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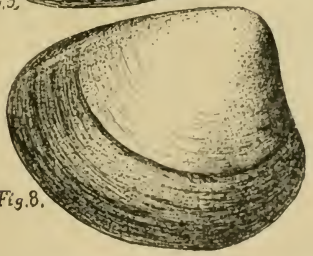
Fig.8.

PLATE VIII.

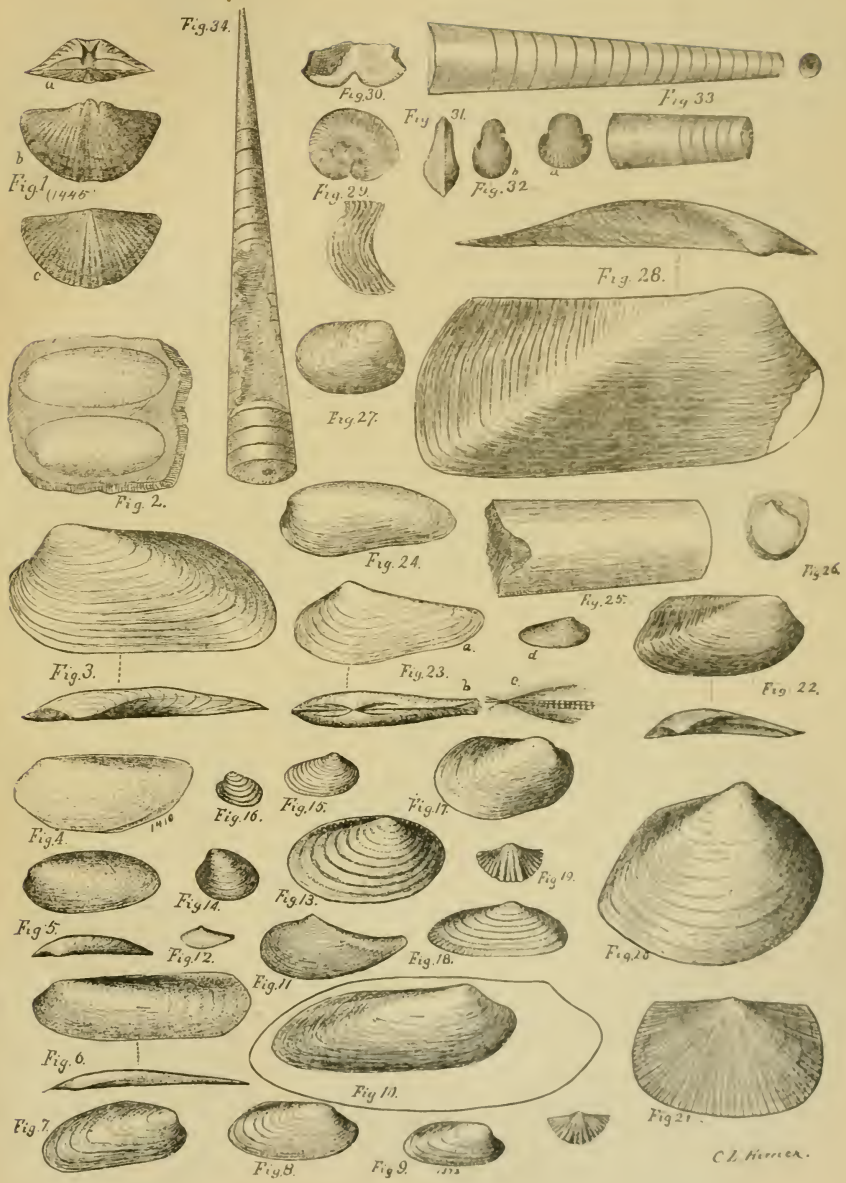
Fig. 34.
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Fig. 21.
C. L. Hansen.

PLATE IX.

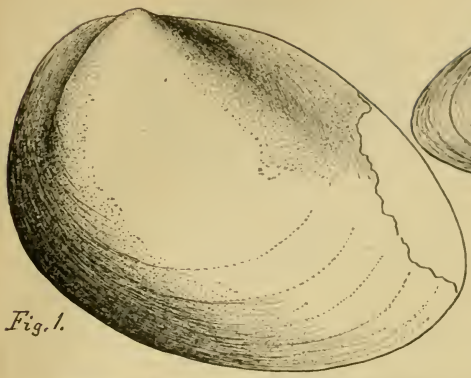

Fig. 1.

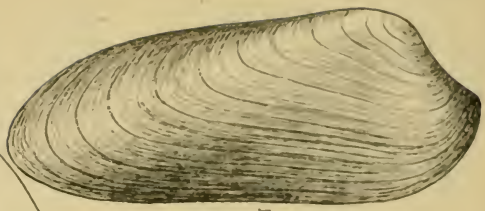

Fig. 2.

Fig. 4.

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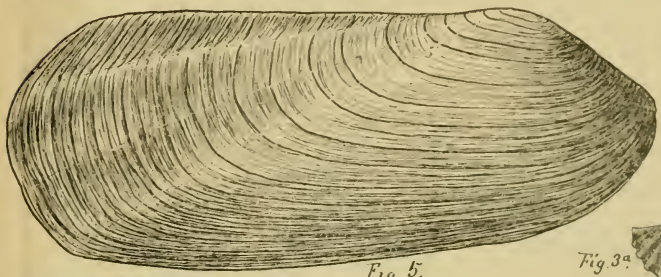

Fig. 5.

Fig. 3a

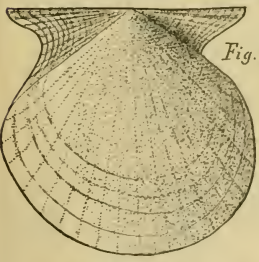

Fig. 7

Fig. 9.

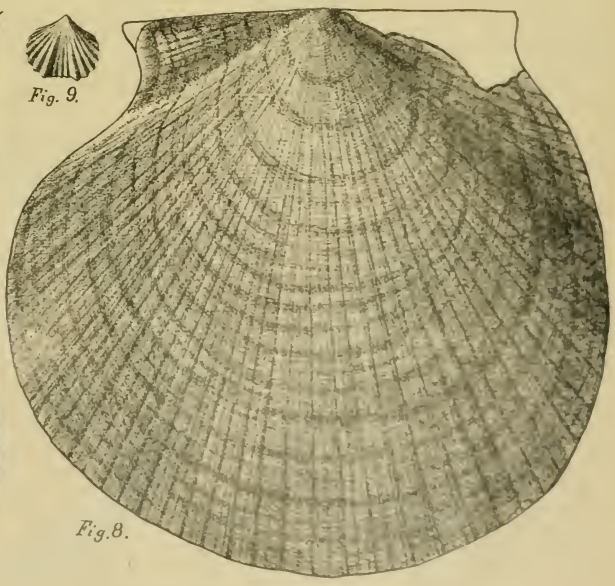

Fig. 8.

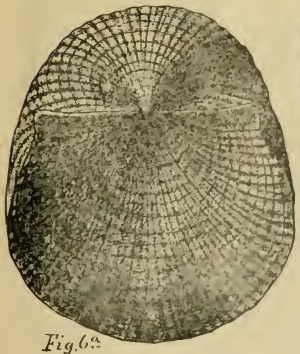

Fig. 6a

PLATE X.

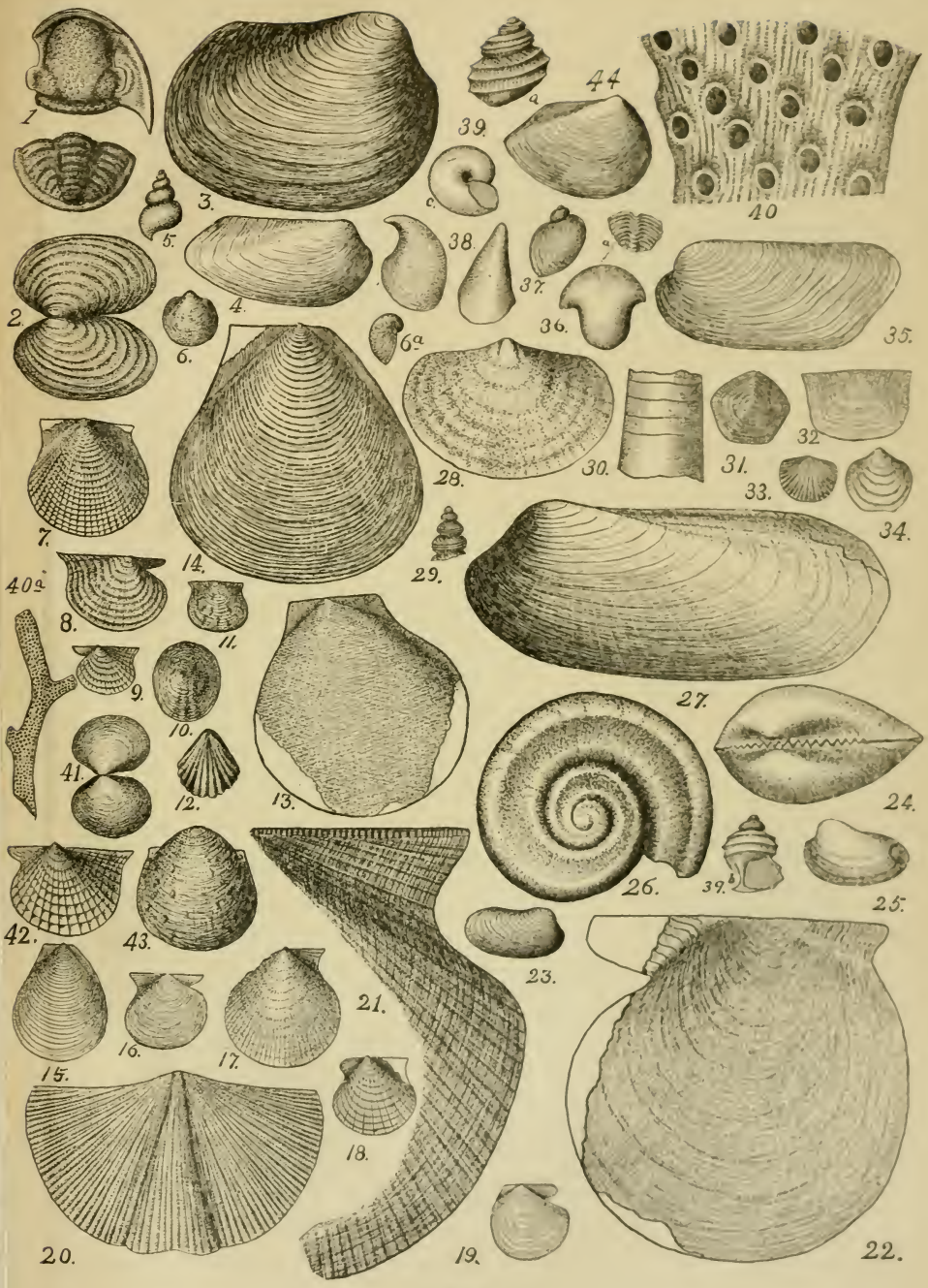
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PLATE XII.

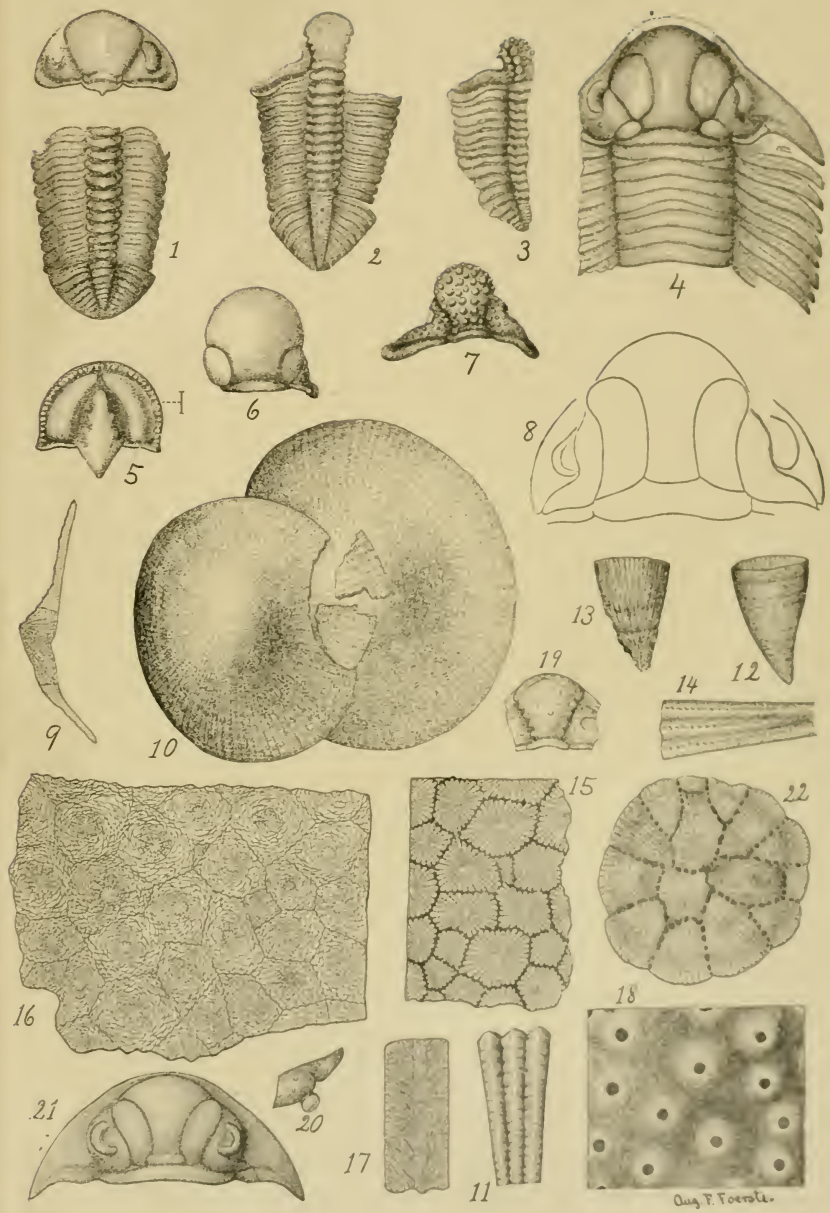
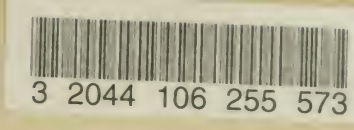


PLATE XIII.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